SPECIAL REPORT

PAGE 133

6 Steps to Better Drafting Practices

Traditional practices are too costly for today's competition. To cut costs, take these steps

OIL, GAS AND PETROCHEMICAL PROCESSING

Petroleum Refiner

AUGUST 1958

VARIABLE DOLLAR

Inflation and Cost Comparisons 101

EASY CHART

Water Content of Natural Gases 153

JOB HELP

What It Takes to Be an Inventor 187

For a "Quick Look" at this issue, turn the page . . .

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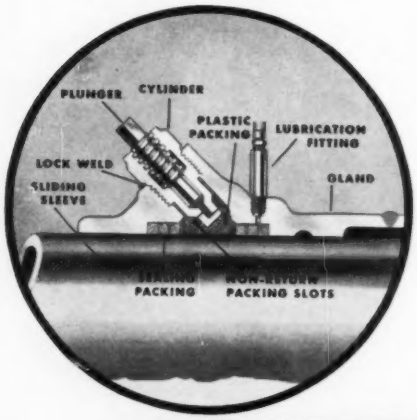
new savings
for expansion joint users

Cross-section of Gun-Pakt feature. To add packing, just add a plug and turn the plunger. Note non-return packing slots at bottom of cylinder.



The Yarway Type W Gun-Pakt Expansion Joint has an improved one-piece design of body and gland and improved method of packing that provide new maintenance economies and greater operating efficiency.

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YARWAY GUN-PAKT

...a good way to specify expansion joints

Volume 37, No. 8 August, 1958

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Petroleum Refiner

OIL, GAS AND PETROCHEMICAL PROCESSING

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A Quick Look

at This Issue

These handy digests permit checking ☑ the articles you want to read first.

☐ **How Inflation Affects Cost Analyses . . .** The dollar continues to decay from year to year. Engineers can no longer ignore the effect of inflation and income tax in cost comparisons made using the capitalized cost method. You can apply this method today. Turn to **Page 101.**

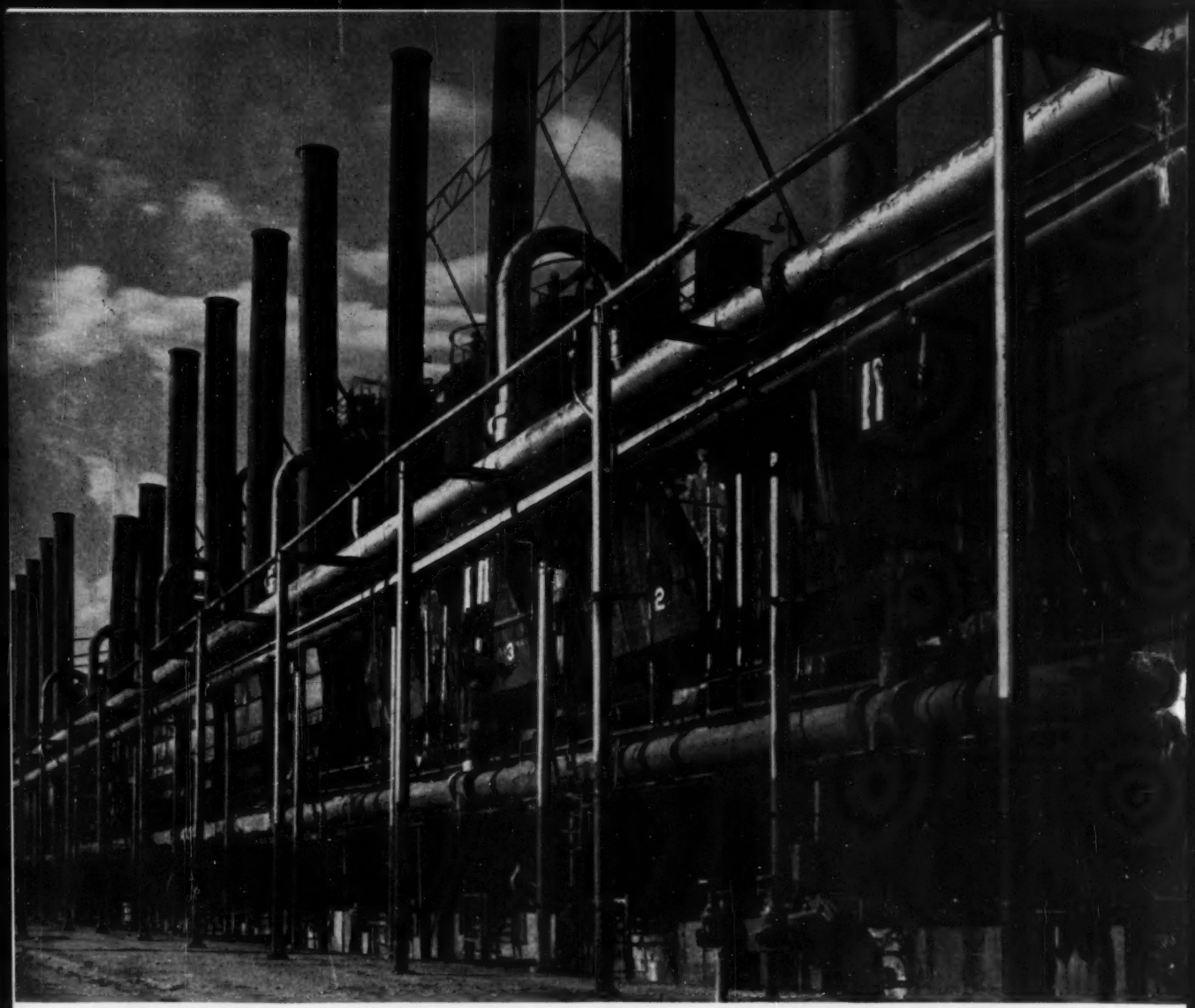
☐ **Can You Justify a CO Boiler? . . .** Although the carbon monoxide boiler is not a panacea in all plants, it may be a money-maker for you. The important variables have been resolved to generalized plots. Check these figures and decide for yourself if your plant can afford to be without a CO boiler. Turn to **Page 107.**

☐ **Applied Hydrocarbon Thermodynamics . . . (Part 8) Polytropic Compression and Expansion . . .** If you ever had to make a trial-and-error calculation to obtain the final temperature and the work done during a polytropic process, you'll appreciate this method of Edmister's. "Fast and accurate"—that's his motto for this whole series. See **Page 113.**

☐ **Urea—the Petrochemical to Watch . . .** Here are ten growth and use patterns of this dynamic triple-threat petrochemical. Having expanded 270 percent in the past eight years, its future is very bright. Currently used predominantly in fertilizers, the resin and animal feed uses are sure to grow. This article is for your planning file. Turn to **Page 123.**

☐ **More Data to Help You Figure Pressure Drop Through Bubble Caps . . .** To get consistantly good results from pressure drop calculations, try this approach which is based on the fundamentals of fluid flow. The author has obtained experimental data to account for aeration. **Page 127.**

Please Turn Page ➡



Photograph courtesy of Standard Oil Company (N. J.)

When are 16 pipe stills as good as 20?

When a Ljungstrom® Air Preheater gives each one 25% greater capacity

You can get 25% greater production from a pipe still when you install a Ljungstrom® Air Preheater. An Air Preheater can raise combustion air temperature as much as 1,000 F by recovering waste heat from the still exhaust. The increase in combustion air temperature permits an important increase in the output of your still per barrel of fuel consumed.

For example, at one East Coast refinery the installation of a Ljungstrom increased the capacity of a pipe still from 16,000 to 18/20,000 barrels. At this same refinery, the installation of a Ljungstrom, together with modern fuel-burning equipment, gave finer product control which boosted product ratings an average of 2 octane numbers for an added annual income of $58,000.

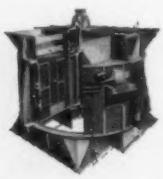
How fast is "WRITE OFF"?

Users report that increased capacity and improved product quality *alone* pay the cost of the Ljungstrom in as little as nine months. You use 20% less of your regular fuel per barrel of output, or you can switch to cheaper fuels that were previously considered useless. Maintenance is less, too, because a Ljungstrom makes the fuel burn more completely, with minimum slag deposits.

For more complete details on what the Ljungstrom Air Preheater can do for you—for an analysis of the heat recovery benefits attainable in fuel-burning equipment—call or write The Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.



The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

A Quick Look at This Issue . . .

☐ **6 Steps To Better Drafting Practices . . .** The first step is to speed up your design and drafting efficiency through drawing techniques that eliminate waste time. The second is through the use of modern ideas such as assembly line methods for vessel design. Step 3 says, "Photos are superfast" for special purposes like alteration drawings. Freehand techniques are not so tough, according to Step 4, when you follow the steps outlined. Step 5 suggests the use of squares and cubes in isometric piping drawings to help the reader visualize non-isometric piping better. By following the drafting room tips in Step 6, speedier drawing will result. For a complete description of each step, turn to the special report on **Page 133.**

☐ **Check Towers for Three-Way Stress . . .** Only by careful analysis of tower stresses can the proper plate thickness be ascertained for towers. This simplified method quickly points out which of the triaxial stresses is maximum. Here's another time-saver for your design notebook. Turn to **Page 149.**

☐ **What Causes Asphalt Failure? . . .** What causes asphalt "break-up"? Why, when tests indicate failure, do some roads continue to perform satisfactorily? Answers to these questions are discussed and physical and chemical change correlated with asphalt failure. Find help for your perplexing asphalt problems by turning to **Page 152.**

☐ **Use This Chart For Water Content of Natural Gases . . .** Here is one convenient working chart showing the water content of different natural gases. The pressure range is from atmospheric to 10,000 psia and the temperature range is from minus 50 to 300 F. You can correct for gases of different gravities and also make corrections if the natural gas was in contact with brine instead of pure water. You'll use this one often. Take a look at **Page 153.**

☐ **Today's New PM Tool—Ultrasonics . . .** Preventive maintenance is the new look for modern refinery and petrochemical plant maintenance programs. The technique of ultrasonic testing allows detection and correction of defects before failure causes downtime in your processes. For complete details, turn to **Page 155.**

☐ **How To Invent . . . (Part I) . . .** If you have never invented anything it does not mean you have no talent for it. More than likely all you lack is the proper training. Here is Part I of a series of articles which will actually teach you the mental techniques of learning to invent plus how to apply those techniques to your daily thinking habits. Turn to **Page 187.**

☐ **Accidents—What Do they Really Cost? . . .** When computing the costs of accidents in today's refinery, too often the only yardstick is the immediate outlay of dollars. Actual analysis has shown that there are many "hidden" costs which should be considered. For a complete rundown on these costs, turn to **Page 193.**

☐ **Do You Use WORD MAGIC? . . .** To get things done in a refinery naturally requires some means of communication. Usually this requires some message to be delivered with words. How successful we are in getting people to do the things we want will depend on our choice of words. Here are some choices that can make a job fail—or succeed. **Page 198.**

A Refining "Hall of Fame"

Next year, 1959, is the one-hundredth anniversary of the beginning of our great oil industry. And to commemorate this occasion, PETROLEUM REFINER will dedicate a major section of its January, 1959, issue to the remarkable development made by the petroleum refining industry in the 100 years since the Drake discovery well.

Among the special features of the Oil Centennial Issue will be a "Hall of Fame" comprising 15 or 20 individuals who have contributed most to the Oil, Gas and Petrochemical processing industry. The editors of PETROLEUM REFINER alone will not select those who should be included. Instead, we are calling on a committee of more than 20,000 persons—the readers of PETROLEUM REFINER.

You are a member of this committee and we would like for you to submit the name of the one man you think has contributed the most to our great processing industry. Granted, it may be difficult to narrow down your selection to one individual, but we would like for you to do some serious thinking and come up with a choice.

Then simply write his name on the special postage-paid postcard on the green page just inside the back cover and drop it in the mail.

We're not setting up special eligibility rules—if you think a man should be nominated, then we do too. When we've heard from those readers who with pride would like to honor the men who have had the big roles in our industry's growth, we are sure to have a list of nominations truly worthy and representative.

From this list, the final choice can be made for the January "Hall of Fame" presentation.

THE EDITORS

New **CROUSE-HINDS**
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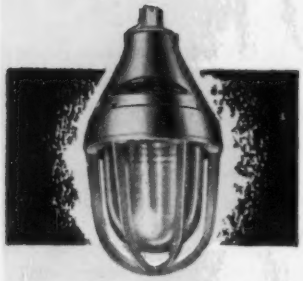

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PETROLEUM REFINER and The REFINERY CATALOG for the oil, gas and petrochemical processing industry.

WORLD OIL (formerly The Oil Weekly) and The COMPOSITE CATALOG for the drilling-producing industry.

PIPE LINE INDUSTRY and The PIPE LINE COMPOSITE CATALOG for the oil and gas pipe line industry.

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For Mr. You et al.

IF YOU'VE BEEN AROUND these parts very long you know how proud PR editors are of the Process Handbook. Well, such a compilation features the 21st annual Special Process Issue scheduled next month. Process Editor Harold Hoffman has performed many important chores during the past six months but we doubt if he's ever been able to get this Handbook job off his mind. It's a big task and we all recognize that fact; so we give it the time and attention it deserves so that it will continue to rate as *the single most authoritative source of process information available anywhere in the world.*

And it's no less. This year some 85 refining processes of current commercial importance will be represented by more than 35 contributors. Recent interest in isomerization, residuum conversion and hydrogen treating has offered new developments and we're covering them. This year's Handbook bonus—there's always a bonus—is a special report on alkylation: types of processes, influence of variables, and how to remedy operating problems. There's even economic data to show what alkylation may be worth to your refinery.

About this very special issue permit this special suggestion: Now's the time to tell those chronic borrowers of your copy of the Handbook to fill in the postcard opposite Page 3 and mail it in. Prompt action will get for them a Handbook of their own. And, as you and they know, it's unbeatable both for current reading and reference.

How a Squib Grows

IF WE WERE LOOKING for an excuse—and we were—for reminding PR readers of several high class reprints immediately available, then an error that crept into a recent squib on this page is sufficient. We were talking awhile back about F. A. Zenz's series on Fluid Catalyst Design Data and inadvertently said it comprised two parts. The figure is EIGHT. But the price still is $1.

Other reprints each bearing the same $1 price tag, which might interest you include:

Foundation Design for Stacks and Towers by V. O. Marshall.

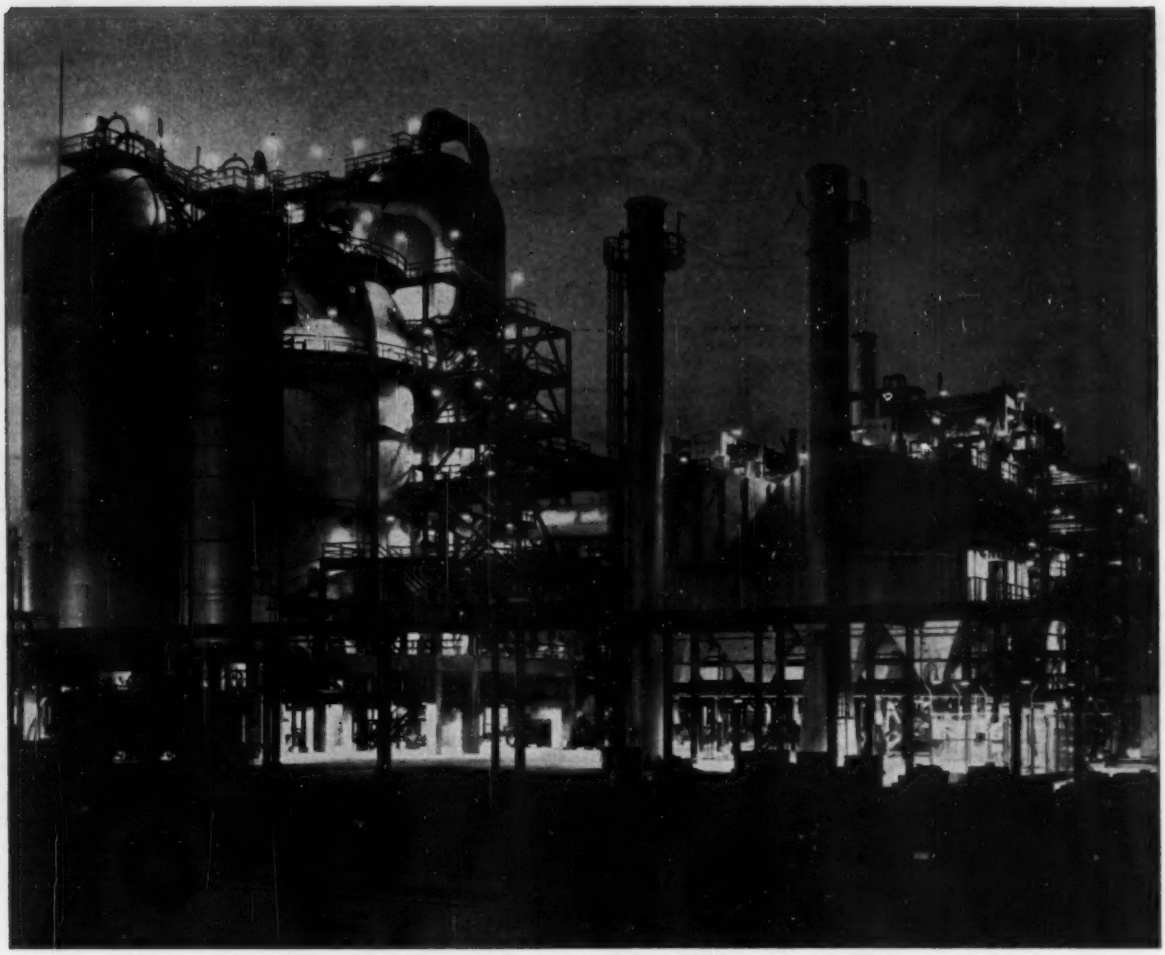
Perforated Trays by C. J. Huang-J. R. Hudson.

Disaster Planning by Don Lambert.

Section II of Application of Thermodynamics to Hydrocarbon Processing by Wayne C. Edmister.

Address Reprints, PETROLEUM REFINER, Box 2608, Houston 1, Texas.

Two *PR* Standbys, Dr. John McKetta, editorial committee chairman, and Dr. Kenneth Kobe, a regular contributor, are editors of the first in a series of 15 annual volumes on "Advances in Petroleum Chemistry and Refining." This work, offered by Interscience Publishers, New York, will summarize past research and forecast future developments of the petrochemical industry.



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Plant and oil refinery engineers have also found that Synthinol 901's superior heat deformation resistance makes it particularly applicable in locations where greater than normal heat conditions exist. In fact, it's now being used in place of Type TA asbestos-covered wire in panel boards and switchboards where high temperatures are known to occur. Rome's Synthinol 901 has proven to be an entirely satisfactory and economical solution to the exacting demands of this type application. Try Rome's Synthinol 901–under your own operating conditions–and see for yourself how well it performs. You'll find it's ideal for low-voltage circuits in refineries, chemical plants, and similar installations where electrical wiring is exposed to corrosive atmospheres.

Specify Rome's Synthinol 901 for your next job. Contact your nearest Rome Cable representative for more information–or write to Dept. 321, Rome Cable Corporation, Rome, N. Y.

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A Quick Look at the Industry THIS MONTH

All Quiet on Mideast Oil Front . . . In spite of everything going on around it, the Middle East oil picture has remained calm and sedate. Many are asking, "How long will it last?" At this point speculation is varied but here are some factors to keep in mind. Nasser is playing a "chosen one" role in his attempt to unite all Arab nations. Previously he was doing it without a big stick—now he has one. With the Iraq coup, Nasser has his hands on one of the big three Mideast oil producers. Iraq, Saudi Arabia and Kuwait together produce about 3 million bpd—more than entire European consumption.

Should Nasser eventually control this oil, it is anybody's guess as to what he would do. Some say he could halt the flow to Europe, but without this market Middle East oil would have little financial value. Others contend pro-Nasserite chauvinism and emotions do not always follow logical paths—three dead Americans, one a Bechtel vice president, bear mute witness to this.

Another point is Russia's long-range plans. As her vast reserves come into production, Russia is exporting more and more oil to countries over the world. Sooner or later Russian oil and Middle East oil will meet head-on in a clash for many world markets—and Nasser knows he can't win this economic showdown.

What about the future—will another hot spot erupt? A good bet is to keep one eye on Africa!

How High Can They Go? . . . Auto spokesmen are putting the bug on the back of refiners as to how high compression ratios can go economically. They say thermal efficiency increases up to 17:1 ratio—maybe even further if engine is radically redesigned. Big question in minds of auto men: Can refining industry economically produce the high octanes needed for those high ratios?

Actually, octane picture hasn't changed in five months. According to Ethyl's octane rating survey of U. S. Gasolines, premium has remained steady at 98.5 F-1 while regular has held to 91.2 F-1.

Shell Shows New Safety Pavement . . . Shell Chemical has new skid-resistant resin safety pavement which enables autos to stop in one-half to three-fourths of distance required on concrete. Substance is poured on concrete or asphalt roads and covered with grit as it hardens.

Residual Fuel Compatibility Gets New Look . . . On the West Coast, compatibility of residual fuel is a problem because of frequent crude source changes. Now, though, refiners there are encouraged by new fundamental approach of applying thermodynamic concepts of solubility. Possibly solubility parameters will replace compatibility standards.

A Quick Look Around the Country . . . Delhi-Taylor may put its 15,000-bpd Port Isabel, Texas, refinery back into part operation soon . . . Interior Secretary Seaton presented to Foreign Petroleum Supply Committee a new "plan of action" under voluntary foreign oil agreement that could move much oil quickly in event Middle East oil is

suddenly cut off . . . **Court turned down Eastern States'** bid for temporary injunction against government's voluntary imports plan—Appellant court, however, reinstated case and returned it to lower tribunal for new hearing . . . **Cities Service** claims new gasoline "additive approach" licks engine rumble (PETROLEUM REFINER, July, 1958, Page 9) noise.

Oil Companies Seeking Change of Venue . . . The 29 oil companies charged with conspiring to raise crude and gasoline prices during Suez crisis are seeking to move the trial from Alexandria, Va., to Tulsa. Contention is because of geographical spread of defendants, Tulsa would be more convenient. U. S. District Judge Albert V. Bryan on Sept. 10 will hear argument for the change.

Those companies preparing for typical drawn-out case marked by delay and procrastination had better reappraise the situation if trial stays in Alexandria. Judge Bryan is member of committee studying methods of speeding up so-called "protracted litigation" of which antitrust and price-fixing cases are often cited as examples.

More Ammonia Capacity Needed by 1975 . . . Although present capacity exceeds demand, latest estimation says synthetic ammonia industry will have to increase output by 80 percent to meet the needs of 1975. Existing capacity, valued at $500 million totals about 10 million pounds a year.

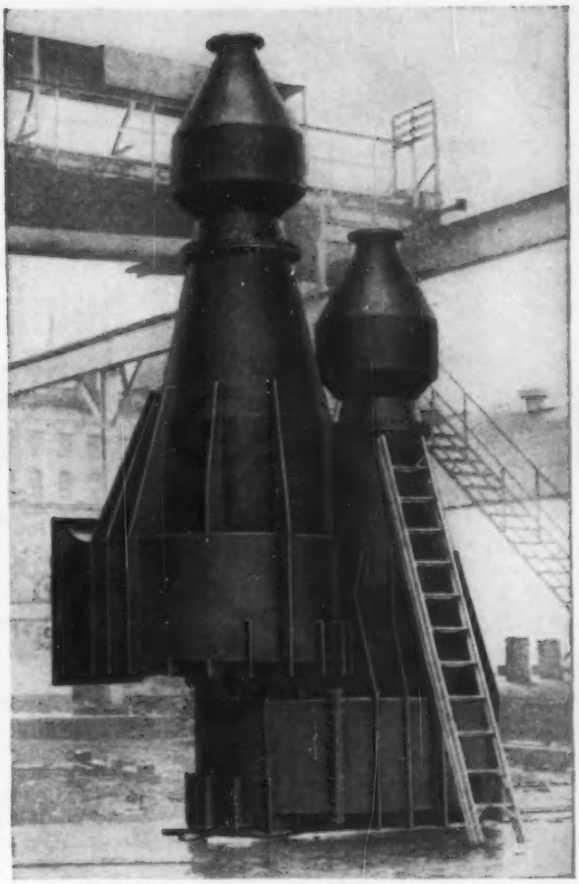
Grease Job to Get Big Play . . . Standard Oil of Kentucky is pushing grease jobs using new moly grease which claims direct benefit to consumer. Reason: latest survey indicates increasing difficulty in getting motorists into station on gasoline performance claims. This verifies recent "Quick Look At Industry" contention (PETROLEUM REFINER, June, 1958, page 9) that motorists are no longer impressed by claims of high octanes and power.

A Little More for a Little Less . . . with recent Amoco Chemical announcement of lower prices for phthalic anhydride (17¢ lb.) and isophthalic acid (15.2¢ lb.) more polyester plastics for less should be forthcoming. Also, lower prices for important plasticizers should add impetus to depth of penetration into materials market. This is true petrochemical progress for consumers (see page 97).

Union Closes Shale Oil Plant . . . Chief shale enthusiast Union Oil of California closed its shale oil operations in Colorado to concentrate on cost and design studies. It's expected operations will be resumed in future to improve present practices. Meanwhile, company is convinced program is successful enough to make U. S. independent of foreign crude in times of emergency like Suez. Presently, however, oversupply of crude overshadows any need for shale.

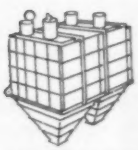
Rival shale company, Oil Shale Corp., Carson City, Colo., is more optimistic, however. Recent company study indicates shale industry is feasible now; that shale oil can be produced in Colorado and delivered to the West Coast for $1.42 to $1.97 a barrel.

Meanwhile, Union Oil expects to start operating this month a 100-ton-per-day experimental tar sands plant using Sisquoc deposits in Santa Barbara County. Diluent will be added to extracted oil which will be piped to Union's Santa Maria coking plant. After coking, lighter fractions will be piped to Oleum refinery.



Exploring new frontiers!

BUELL CYCLONES



"SF" ELECTRIC PRECIPITATORS

PRECIPITATOR-CYCLONE COMBINATIONS

But these aren't satellite launchers, though they're specially designed for high temperature operation: they're Buell extra-efficient cyclone dust collectors . . . and the new frontiers they're exploring are in industry. Everywhere in American industry, from cement mills to refineries, from chemical plants to power generating stations, Buell collectors set new records in percentage of dust removed, low maintenance, and improved plant operation. Even in the age-old field of fly ash collection, Buell extra efficiency pays off. Only *Buell* cyclones have the unique Shave-off port that traps small fines in the double eddy currents. And Buell large-diameter design eliminates bridging, clogging, or plugging. *All three* Buell Systems are illustrated and described in "The Collection and Recovery of Industrial Dusts". Write for a copy to Dept. 21-H, Buell Engineering Company, Inc., 123 William St., New York 38, N. Y.

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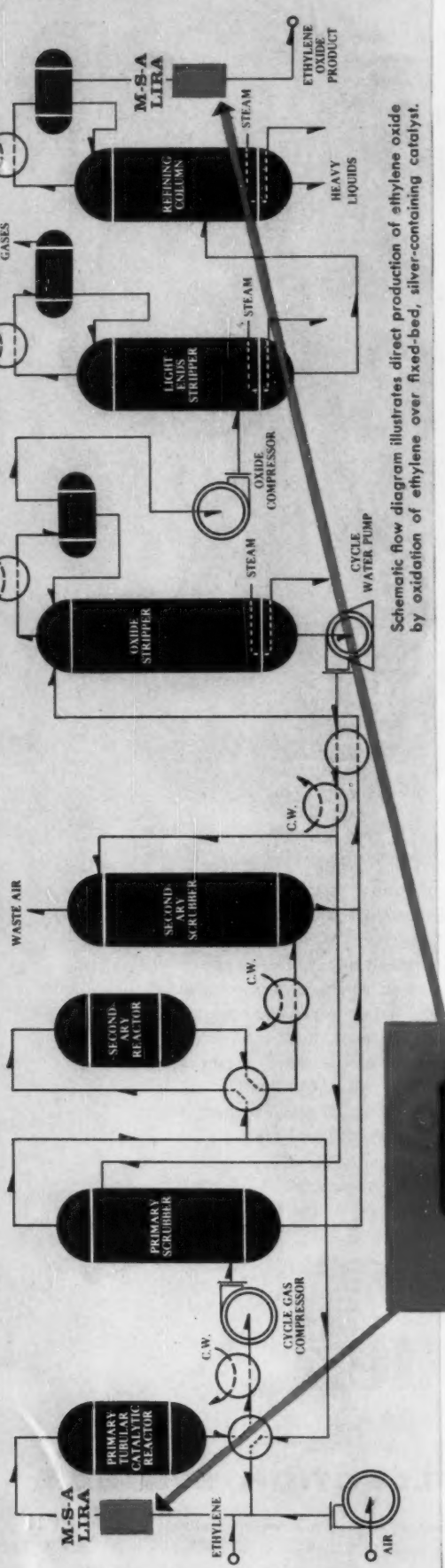


Schematic flow diagram illustrates direct production of ethylene oxide by oxidation of ethylene over fixed-bed, silver-containing catalyst.

ANOTHER PROBLEM-SOLVING APPLICATION OF M-S-A® LIRA ANALYZERS:

helping to keep reactors operating at peak efficiency in ethylene oxide plants

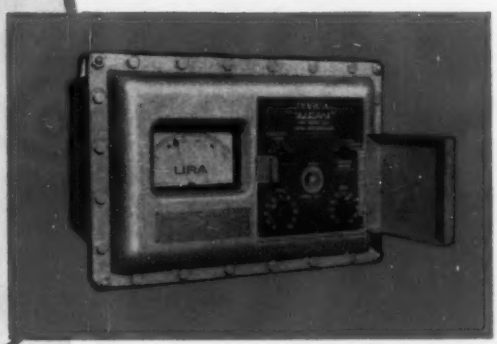
Catalytically oxidizing ethylene to ethylene oxide? You can do it safer, at a greater rate, at less cost by measuring both ethylene input and ethylene oxide product with M-S-A LIRA Model 200 Infra-Red Analyzers

M-S-A LIRA Analyzers can save more than they cost in a matter of months. And they can contribute mightily toward bringing the plant to peak efficiency.

A striking example of this interesting claim is the use of Model 200 LIRA Analyzers in processing ethylene oxide by direct oxidation of ethylene. In this process, LIRAs are used to measure the ethylene in relation to the oxygen input into the reactor. This in turn assures peak operating efficiency of the reactor.

The Model 200 is also used in this process to measure the purity of ethylene oxide being produced as the final product. No need for manual tests for product quality. It's automatic. Continuous. And that's where some of the biggest savings lie. Let's face it: manpower used in process monitoring is expensive. So, let the LIRA do it.

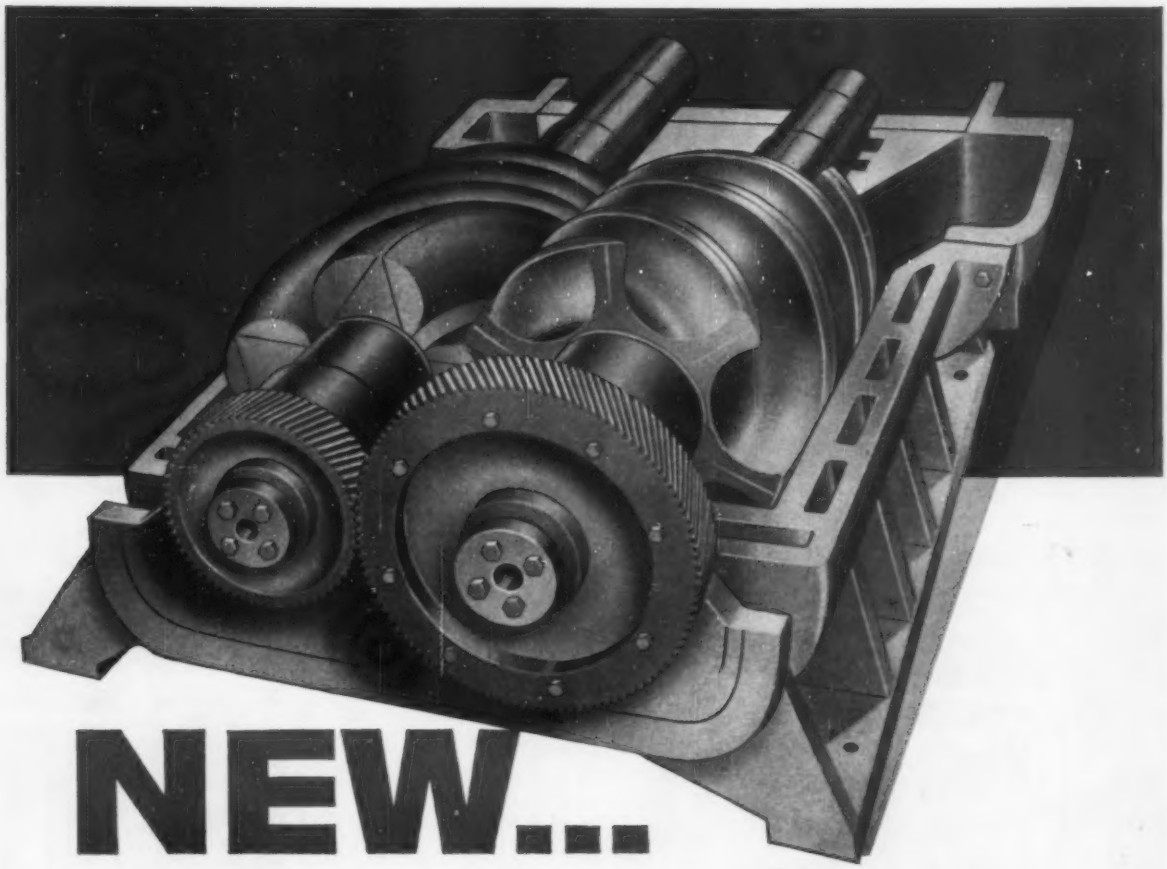
An M-S-A Instrument Specialist will be happy to put our ingenuity to work on your process stream problems: safety, product quality, measurement or control. Consult him. Or write us for helpful literature.



Explosion-proof Model 200 has a tamper-proof lock. All self-checking circuit controls are easily accessible through the explosion-proof enclosure.

INSTRUMENT DIVISION

Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania



NEW...

Fairbanks-Morse Positive Displacement Axial-Flow Rotary Compressor

Combines the best features of reciprocating and centrifugal compressors

Consider the advantages of the all-new Fairbanks-Morse two-impeller, helical-lobe type, axial-flow rotary compressor:

1 Delivers oil-free air or gas with low ratios of unit weight and space to capacity.

2 Exhibits high efficiencies and positive-displacement stability of flow at varying compression ratios and speeds.

Result: Ideal performance from a relatively small compressor that is mechanically simple, flexible in application, adaptable to any power source; a compressor that provides stable performance, smooth operation, and variable-capacity control.

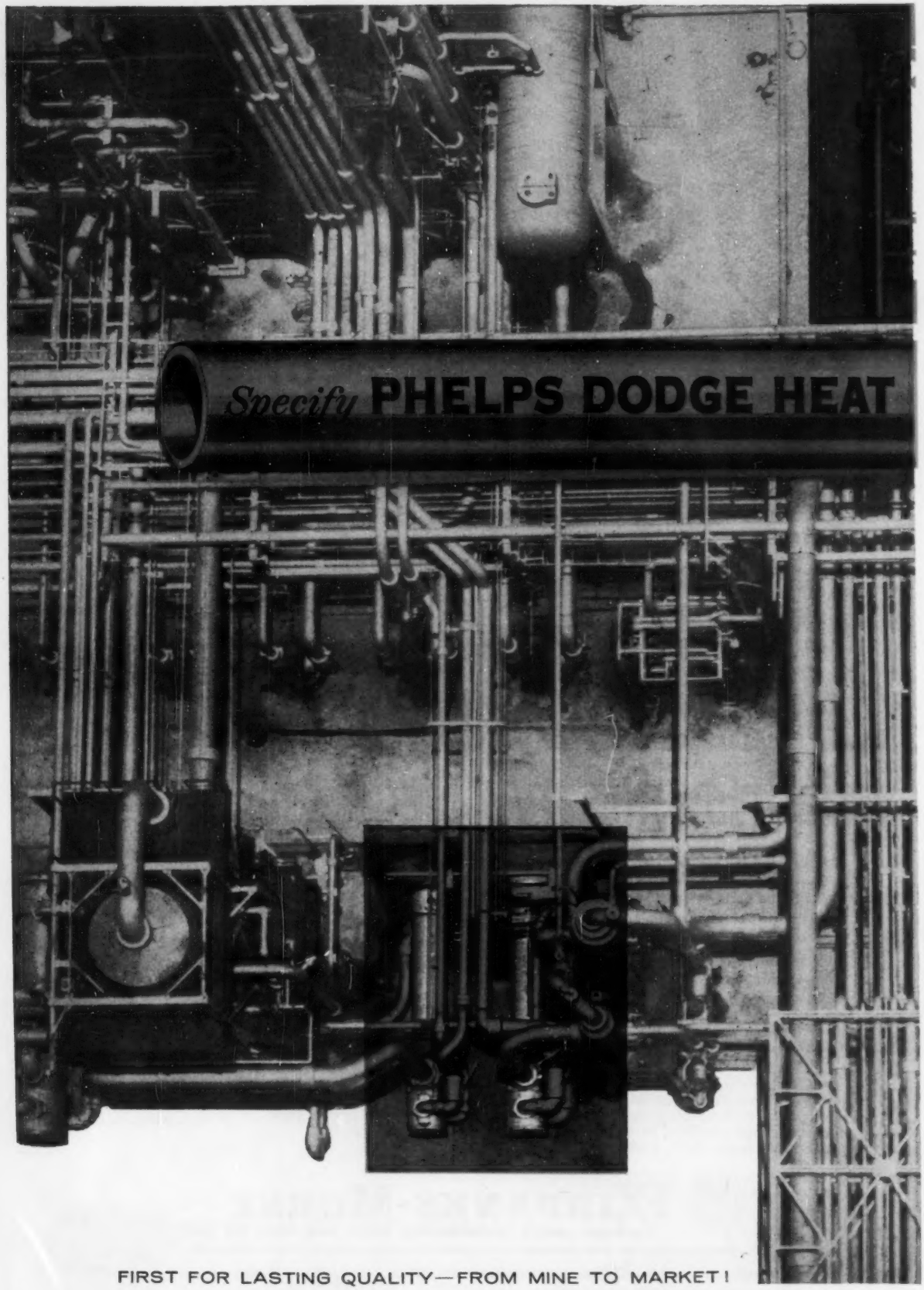
This all-new F-M Compressor is available in 5 standard case and impeller sizes, single-stage and multi-stage units—for pressure, vacuum or booster service. Capacities range from 800 to 13,000 cfm.—also higher or lower if desired, on custom-designed basis. Contact your Fairbanks-Morse branch for further information, or write directly to Fairbanks, Morse & Co., 600 So. Michigan Ave., Chicago 5, Illinois.

Ask for new illustrated bulletin ACO 100.1 giving typical performance characteristics and other important data.

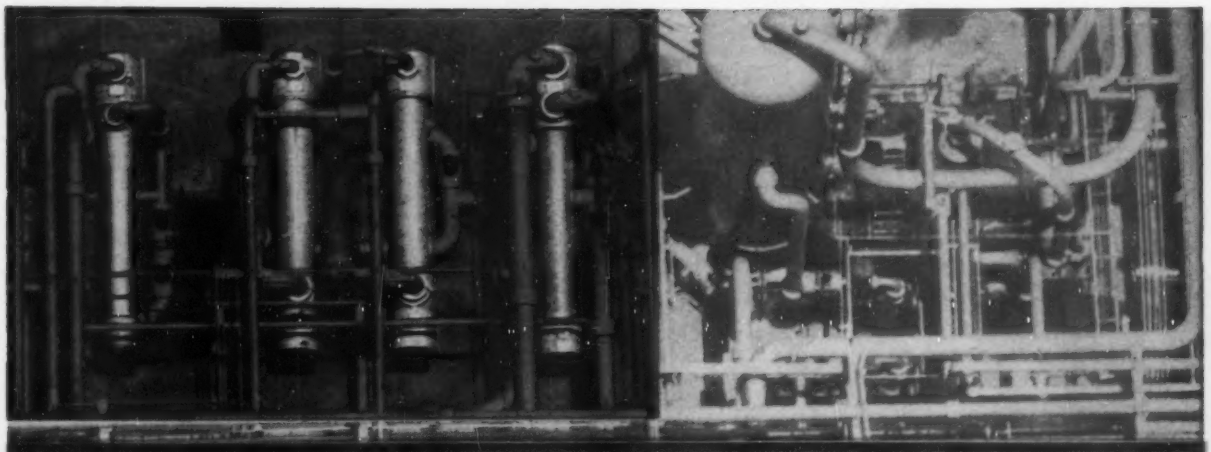
FAIRBANKS-MORSE

a name worth remembering when you want the BEST

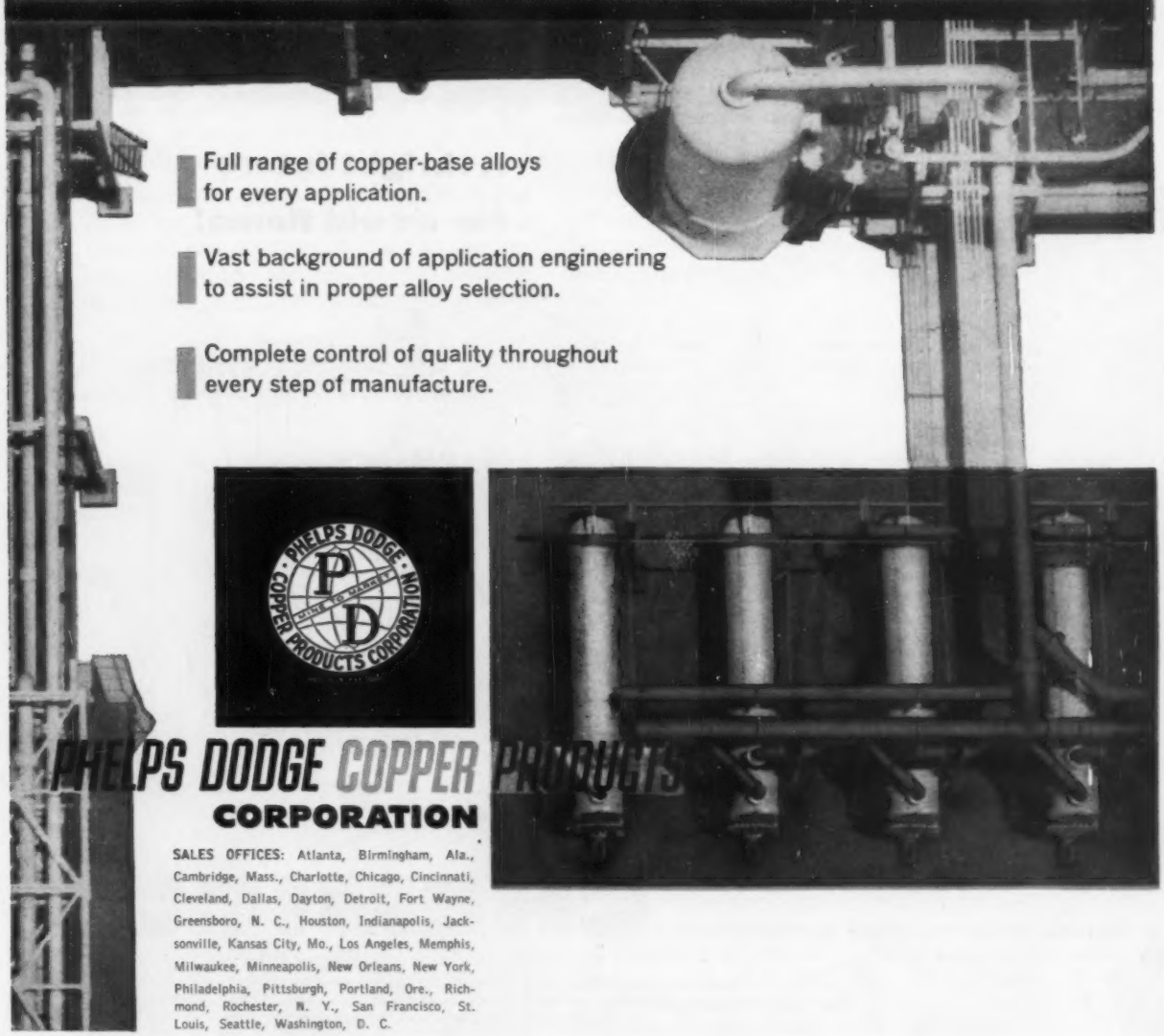
COMPRESSORS • ELECTRICAL MACHINERY • DIESEL AND DUAL FUEL ENGINES • DIESEL LOCOMOTIVES • RAIL CARS • PUMPS • SCALES • HOME WATER SERVICE EQUIPMENT • MAGNETOS



FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!



EXCHANGER TUBES *for Longer Service!*

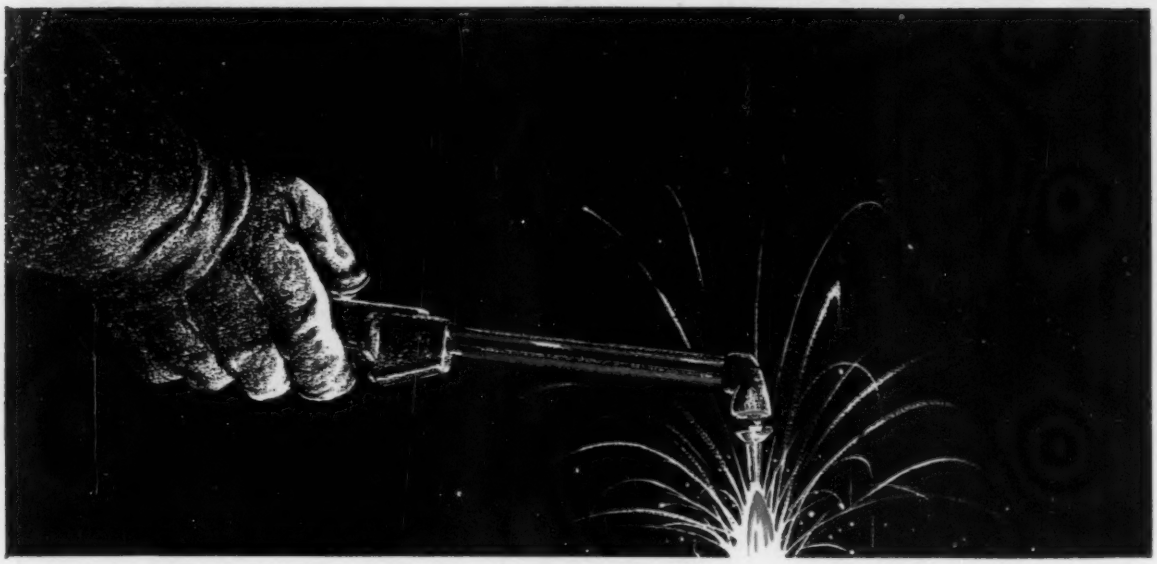


- Full range of copper-base alloys for every application.
- Vast background of application engineering to assist in proper alloy selection.
- Complete control of quality throughout every step of manufacture.

PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Cambridge, Mass., Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Dayton, Detroit, Fort Wayne, Greensboro, N. C., Houston, Indianapolis, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

For more data on advertised products, use Readers' Service Cards, last page.



ACETYLENE

...bright future for an old flame!

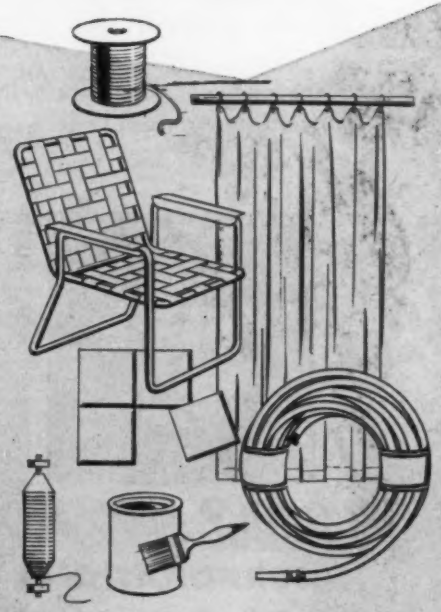
For years the use of acetylene commercially was limited primarily to the welding torch. Today, it is one of the brightest stars on the petrochemical horizon, with some 80% of total output serving as basic raw material for many of the "miracle" synthetic fibres and hundreds of other important plastic products, including *acrylic fibres, resins, solvents,* and *synthetic rubber.*

Key factor in the phenomenal growth of acetylene has been the recent development of processes for its production from natural gas. Among these new production techniques, the BASF process has had the greatest success, because of its commercially proven economy, safety and reliability.

With exclusive rights in all North American countries* for the BASF process, Chemico has designed and constructed facilities for the production of more than 150,000,000 pounds per year capacity of acetylene. This total includes the world's largest plant for producing acetylene from natural gas. This experience enables CHEMICO's highly skilled staff to handle acetylene projects with maximum efficiency and economy.

*On occasion those rights have been extended to other areas, through special arrangement with BASF.

If you are interested in the profit making opportunities offered by acetylene, we suggest you send for CHEMICO's new acetylene brochure (Bulletin No. 257), which will give you more detailed information on the BASF process and CHEMICO's experience in this field.



CHEMICAL CONSTRUCTION CORPORATION

CHEMICO

A SUBSIDIARY OF ELECTRIC BOND AND SHARE COMPANY

525 West 43rd Street, New York 36, N. Y. • Cable Address: CHEMICONST, New York

Affiliated Company: CHEMICAL CONSTRUCTION (GREAT BRITAIN) LTD., LONDON, ENGLAND

REPRESENTATIVES in JOHANNESBURG • PARIS • TOKYO

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What *lead does to control corrosion*

in producing and storing Phosphoric Acid

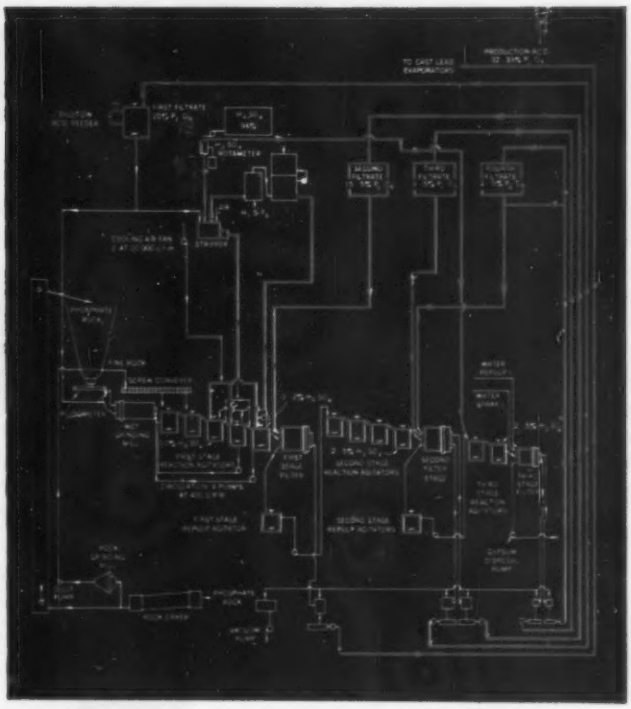
H_2SO_4 and P_2O_5 are a hungry pair.

They eat right into most metals. But *lead* takes the sharp edge off their hunger quickly.

With each of these chemicals, *lead* reacts on contact to form on the surface of the metal an insoluble and impervious film. This film stops further corrosion.

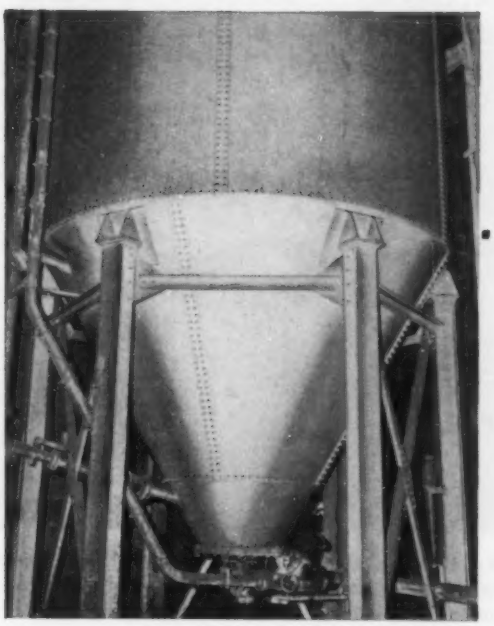
That's why *lead* has long been a "first choice" material in much of the equipment used for treating phosphate rock with sulfuric acid to produce phosphoric acid. It is used for lining vessels and tanks, in piping and pumps, in evaporator coils and for raking blades in agitators.

Recently new forms of cage-type sheet *lead* structures, new bonding and strap-lining methods, new constructions for high-temperature erosion-corrosion service and automatic stud welding techniques, have increased *lead's* usefulness . . . not only in phosphoric production but in many other applications.



What about *lead* for your own acid handling equipment . . . considered in the light of these new techniques! It's something to think about, and . . .

When you think of Lead . . .



think of National Lead Pressure Vessels

. . . lead-lined to last

Today, National Lead weds *lead* to steel . . . not only in pipe (Tubond®) and fittings (United®) but in massive and complex process and storage and shipping vessels, as well. In this equipment, the union is stronger than the tensile strength of *lead*. Bonded lead linings minimize troubles from vibration and severe and rapid cyclic temperature and pressure changes which can result in blistering, buckling and cracking. Creep is virtually eliminated.

In view of this and other developments, you may want to review your position on *lead-lined* tanks, stills, scrubbers, filters, piping, valves and other corrosion resisting equipment. If so, contact National Lead Company, Lead Lined Products, 111 Broadway, New York 6, N. Y.

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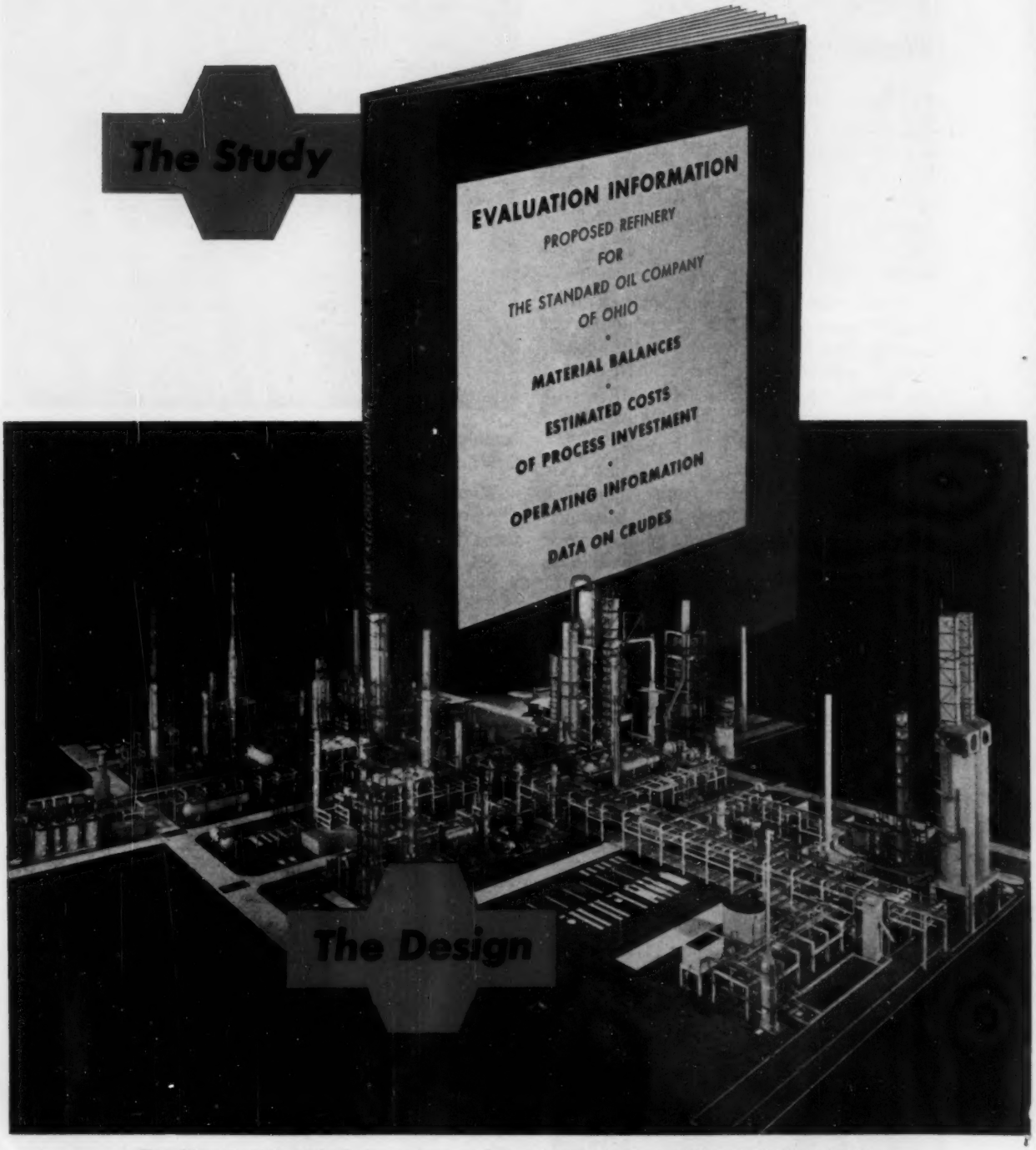
BLUEPRINT for



To achieve the ultimate in design, yet assure the most economic plant, Kellogg built this 26' x 29' scale model concurrently with designs to assist all levels of management, as well as all categories of engineering and refinery personnel, in design reviews well in advance of major construction.

For more data on advertised products, use Readers' Service Cards, last page.

Economic Achievement

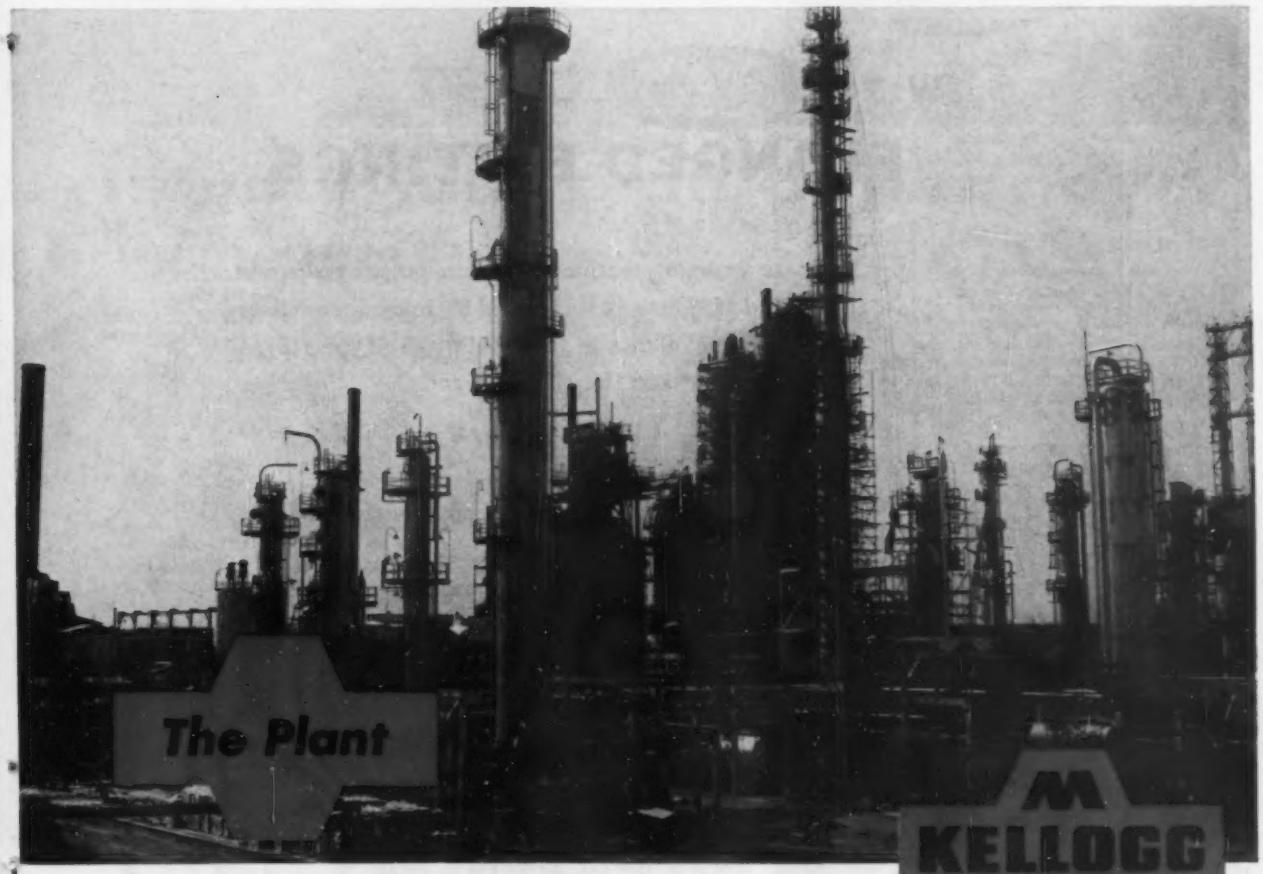
When refining capacity must be increased, an oil company's planning group has to evaluate the technical and economic pros and cons of modernizing by degree or scrapping outmoded facilities and rebuilding completely. When the decision is to start from scratch, hundreds of variables are involved in choosing location, type and range of crudes, product mix, process line up, degree of integration, and refinery size. Which combination will insure the optimum in efficiency, economy, yields, flexibility for the future, and return on investment?

Faced with exactly this time-consuming multiplicity of problems, The Standard Oil Company of Ohio first scheduled decision deadlines for each planning phase, then called upon Kellogg for refinery material balances, estimated process investment costs, operating information, and data on various crudes. Decisions from this study, each made on schedule, served as the blueprint for Kellogg's second assignment—engineering and constructing an integrated new plant at Toledo, Ohio. Designed for a capacity of 60,000 BPSD, this $40 million refinery is an outstanding example of sound economics at work in plant planning and execution.

With most oil companies concerned with tomorrow, there is no better time to be discussing future plans and problems with Kellogg than today. Kellogg's Contract Sales Division welcomes the opportunity to put its coordinated engineering, procurement, and construction services at your disposal.

THE M. W. KELLOGG COMPANY
711 THIRD AVENUE, NEW YORK 17, N. Y.
A SUBSIDIARY OF PULLMAN INCORPORATED
The Canadian Kellogg Co. Ltd., Toronto • Kellogg International Corp., London
Kellogg Pan American Corp., New York • Societe Kellogg, Paris • Companhia
Kellogg Brasileira, Rio de Janeiro • Compania Kellogg de Venezuela, Caracas

For the complete story on this refinery, send for our new 20-page Kelloggram



Construction almost completed, the major sections of the integrated refinery shape up as: (left to right) the saturate gas plant, the crude section, catalytic cracker, unsaturate gas plant, catalytic polymerization section, and the delayed coker.

For more data on advertised products, use Readers' Service Cards, last page.

BUTT IT... **BOLT IT...AND BEAT CORROSION**

WITH ESCO CAST FLANGED FITTINGS

Faces are accurately machined to insure proper gasket seat. 150-pound MSS fittings are stocked for immediate delivery in a full range of sizes in *ESCO* Alloy 45 (Type 316), 40 (Type 304), 20* and Hastelloy** B and C.

Heavy flanged (ASA) Fittings are available in working pressures to 900 pounds.

Special Cast Flanged Fittings of any design or stainless analyses can be made on order.

Whatever your heat, corrosion, or abrasion problem there is an *ESCO* Cast Alloy that's *right* for the job.

*Duriron Licensee **Haynes-Stellite Licensee

See your ESCO Dealer. Ask for Catalog No. 175.

ESCO®

ELECTRIC STEEL FOUNDRY COMPANY

2164 N. W. 25TH AVE. • PORTLAND 10, OREGON

MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.

Offices in Most Principal Cities

ESCO INTERNATIONAL, NEW YORK, N. Y.

IN CANADA ESCO LIMITED

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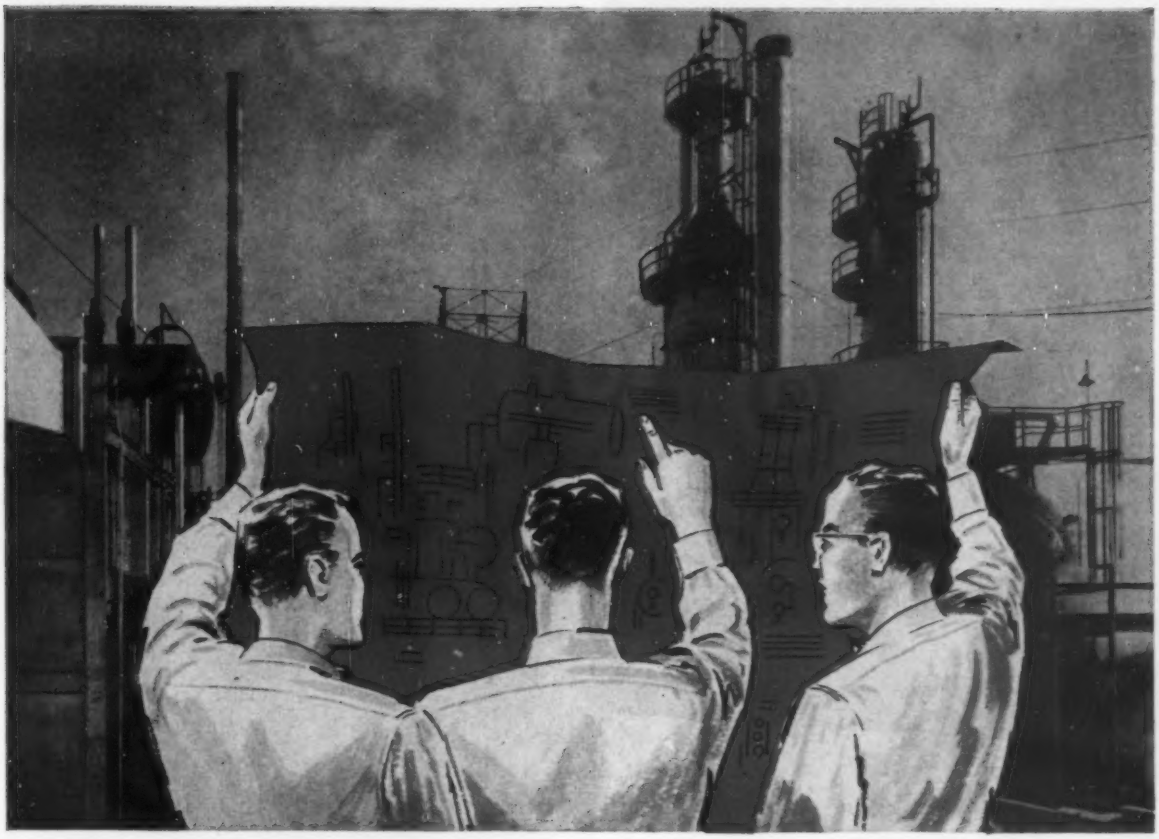

Is your future on paper now?

YOUR FUTURE BEGINS with an arc and a line, with dimensions and specifications. How your future *extends* from these plans on paper depends largely on the skills and facilities of the men who build from these masterful markings.

One thing is sure. For your petrochemical processing equipment, you *can* depend on the skills and facilities of Bros Incorporated—steel plate fabricators for the nation since 1882.

Fractionating towers, pressure vessels, autoclaves, stacks and storage tanks—these are some of the special fabrications of large and small capacities that Bros builds. All in a long tradition of exact conformance to prints and specifications.

And, if you need expert assistance in the planning and design of your process equipment, the Bros team of 350 engineers, designers and specialists in steel plate fabrication are yours to command.

Bros has modern shop facilities for welding and working steel plate up to 2" thick. Fabrications conform to all accepted code requirements. X-ray and annealing facilities, too, are available.

When required, skilled Bros field crews go where needed to erect units too large for such limiting conditions as shop and shipping clearances.

Today more and more industries are looking to Bros for their steel plate fabrication needs. So if your future is on paper, now is the time to bring Bros into the picture.

Bros also manufactures package and field erected boilers and stokers to supply all your steam generation requirements.

Call your BROS *sales engineer today!*

BROS NATIONAL DEALERS

BIRMINGHAM—Palmer & Lawrence
BISMARCK—Lignite Combustion Engineering Corp.
CHICAGO—D. H. Skeen and Company
DALLAS—Mechanical Specialty Co.
DENVER—The Lucas Engrg. Co.
DETROIT—Wayne Boiler & Equip. Co.
DULUTH—Williams-Swanson Co.
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BROS *Incorporated*

General Sales Division

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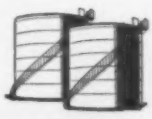
BROS

PACKAGE BOILERS

AUTOCLAVES

FRACTIONATING TOWERS



STORAGE TANKS

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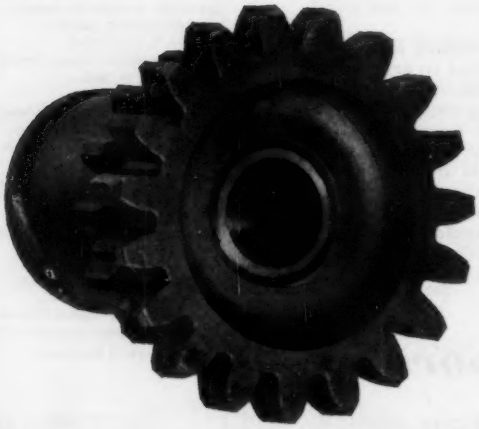
CORROSION REALLY STOPPED!



Gears and pistons were used to illustrate the damage of corrosion more vividly. The basic idea of the ASTM Steam Turbine Oil Test in which probes are ordinarily used was not changed.

ARMOUR DUOMEENS® OFFER COMPLETE PROTECTION AGAINST CORROSION!

Here you see 2 pistons and gears after 20 hours in a modified ASTM Steam Turbine Oil Test. The piston and gear in the "control" oil-brine solution were badly corroded. *There was no corrosion on the lower piston and gear when only 60 ppm Duomeen salt was added to an identical solution. Both parts stayed as shiny and clean as when the test began!*

It is hypothesized that the Duomeen plated-out on the metal surface as a closely-packed mono-molecular film, enabling the surface to become preferentially oil-wettable. By such action, a highly effective diffusion barrier is formed, even at very low concentrations, which acts to inhibit corrosion.

Versatile Duomeens make all refinery products function better

Because these oil soluble organics are selectively adsorbed from oil to metal, they function as product additives, process corrosion inhibitors, and as chemical intermediates.

Diesel oils, lube oils, aviation gasolines, greases, automobile gasolines, #2 fuel oils—all can benefit from the Duomeens and other fatty amine derivatives in the following ways . . .

- Corrosion inhibitors in refinery products
- Sludge inhibitors in fuels and oils
- E.P. lubricants in hi-pressure oils and greases
- Oiliness agents in oils and greases
- De-icers in gasolines

These di-polar surface active agents are also being utilized in many other applications.

Refineries are using them as corrosion inhibitors throughout the entire refining process. Because of their adaptability, they have few equals when used as chemical intermediates. And new uses are still being discovered for the Duomeens.

Armour petroleum specialists will help you utilize the right organic for your finished products, your flow lines and equipment. There is a Duomeen—or a Duomeen derivative—specifically designed to solve almost any refinery problem.

Send for the new Duomeen booklet, product samples and application information.

ARMOUR CHEMICAL DIVISION

Leader in Progressive Fatty Acid Chemistry

© Armour and Company • 1355 West 31st St. • Chicago 9, Ill.

Should your Mechanical Superintendent influence heat exchanger design?

Question: What can Mechanical Superintendents contribute to the design of quality process heat exchangers?

Answer: By offering their knowledge of the operation of heat exchangers under process conditions, they can help Project Engineers to anticipate maintenance problems during the design phase — and at Western . . .

. . . we welcome the "pre-fabrication" aid of Mechanical Superintendents whose practical experience in the operation of heat transfer equipment has been of great value in designing heat exchangers for long service at low maintenance.

Working with their Engineering Departments, Mechanical Superintendents can offer . . .

. . . information on the fouling characteristics inherent in a specific application

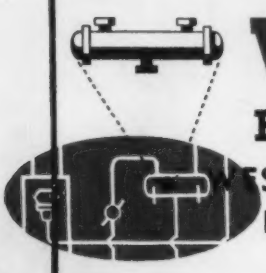
. . . mechanics of easier physical handling of each exchanger during cleaning and inspection

. . . practical recommendations on the selection of metals

. . . advice on the desirability of paralleling exchangers for more efficient operation and lower maintenance

Reduced maintenance with a minimum of downtime has become a characteristic of every Western heat exchanger, by augmenting Western's own knowledge of operational problems with the experience of our customers' Engineering and Maintenance departments.

From design to fabrication, quality and satisfaction is designed into Western heat exchangers.



WESTERN
HEAT EXCHANGERS
WESTERN SUPPLY COMPANY
P.O. Box 1888 – Tulsa, Oklahoma

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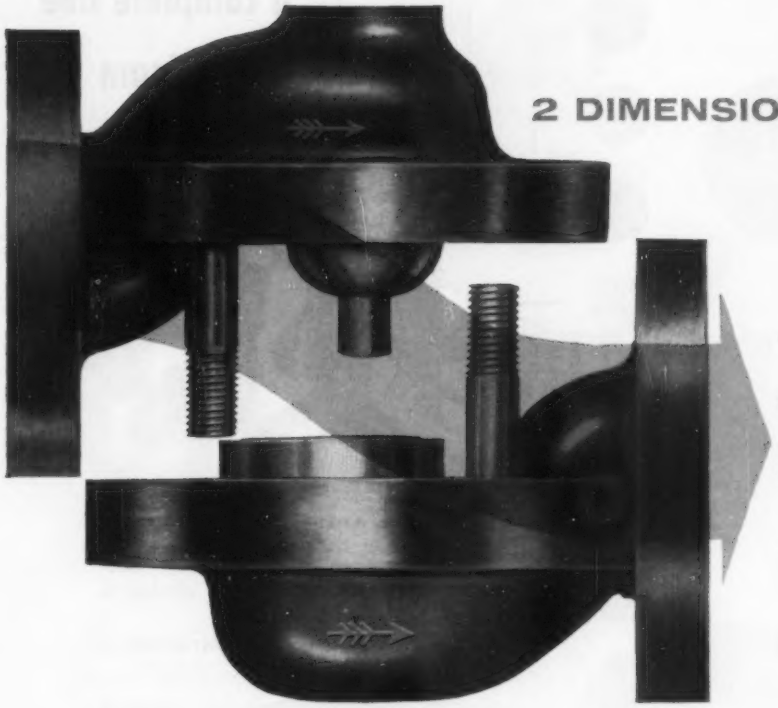


2 DIMENSIONS . . . C_v and f. to f.

. . . that mean greater savings and flexibility with K&M split-body valves

The "dollar dimension" of a valve is the C_v; flow capacity, rather than the nominal size.

K&M split body valves have higher C_v's than any other split-body design. This was achieved by generous internal dimensioning, well-engineered contouring and quality-controlled manufacture.

The accompanying table of C_v's was not arrived at by estimate, calculation or optimism. K&M's larger flow ratings are certified by actual hydraulic laboratory tests.

. . . And you can start using this greater capacity on existing installations because of another important dimension . . . face-to-face.

K&M is the only split body valve conforming to I.S.A. face-to-face standards, (150, 300, 600 psi).

These K&M valves can, therefore, be interchanged with any standard diaphragm valve in your plant.

Here's money saving for your valve inventory budget . . . and essential flexibility for your plant.

The same body can be field-converted into any one of 432 different valve assemblies . . . in a matter of minutes . . . and without removing the valve from the line.

Write for Bulletin 132 which completely describes the valve which has been "dimensioned" to save you money.

COMPARISON OF FLOW CAPACITIES (C_v)

Valve Size	K&M	Valve B	Valve C
½	5.7	4.0	3.0
¾	7.0	6.0	5.0
1	14.0	12.0	9.0
1½	31.5	25.0	24.0
2	49.5	46.0	38.0
3	121.5	110.0	96.0
4	197.0	195.0	150.0
6	405.0	400.0	—
8	645.0	640.0	—

K&M

diaphragm control valves

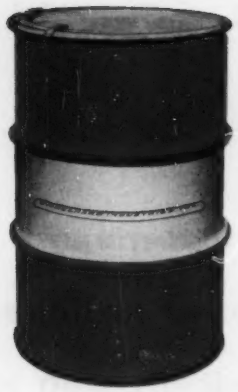
Our 79th Year

KIELEY & MUELLER, INCORPORATED

Oldest Pressure and Level Control Valve Manufacturer

64 Genung Street, Middletown, New York

S.A. 1690



higher octane levels and longer catalyst life...with existing equipment

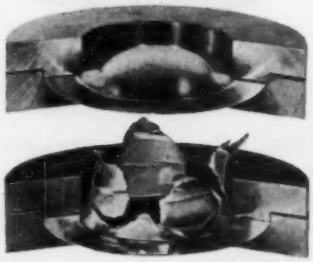
If you have the problem of increasing octane rating and production, investigate Sinclair-Baker RD 150! You can do it with your existing equipment, merely by replacing with Sinclair-Baker RD 150 Platinum Catalyst. Its efficiency in producing important yield increases at high octane levels is a matter of record. The long period of RD 150 operation is unmatched by any other catalyst . . . further, it is regenerative in situ! Costs are sharply reduced to lowest level. A representative will be glad to give you detailed information upon request. All data of confidential nature are of course treated accordingly. Literature is available.

CHEMICAL DIVISION • 113 ASTOR STREET
NEWARK, N.J.

a complete line of platinum laboratory ware

All standard forms and sizes for chemical and physical purposes, made of platinum or any desired alloy. Line includes crucibles, reshapers, triangles, dishes, electrodes, anodes and cathodes. A catalog is available upon request.

BAKER PLATINUM DIVISION • 113 ASTOR STREET
NEWARK, N.J.



instant automatic release of excess pressure

Platinum, gold, and silver are now generally recognized as specifics when dealing with corrosion. Each is resistant to the corrosive effects of an important group of liquids and gases and will remain unattacked under conditions that would render many base metal materials useless. These rupture discs, depending on material selected, are guaranteed to be burst ± 5% of specified pressure.

BAKER PLATINUM DIVISION • 113 ASTOR STREET
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CHEMICAL DIVISION

ENGELHARD INDUSTRIES, INC.

EXECUTIVE OFFICES:
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BAKER PLATINUM DIVISION

SAVE maintenance

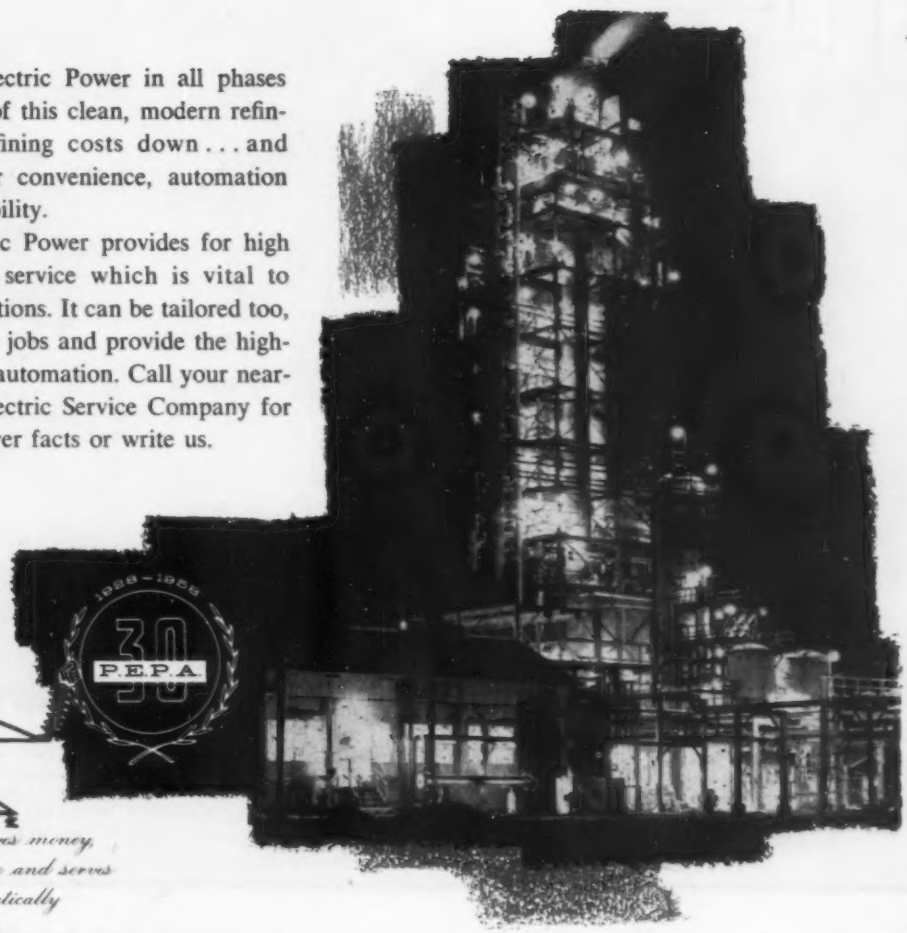
SAVE manpower

SAVE with Electric Power

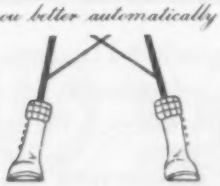
SAVE money

Purchased Electric Power in all phases of operation of this clean, modern refinery holds refining costs down . . . and means greater convenience, automation and dependability.

Utility Electric Power provides for high continuity of service which is vital to refining operations. It can be tailored too, for individual jobs and provide the highest degree of automation. Call your nearest Utility Electric Service Company for complete power facts or write us.



Electric Power . . . saves money, manpower, maintenance and serves you better automatically



Petroleum Electric Power Association

P.O. BOX 35006, DALLAS 35, TEXAS

For more data on advertised products, use Readers' Service Cards, last page.

POWELL

world's largest family of valves

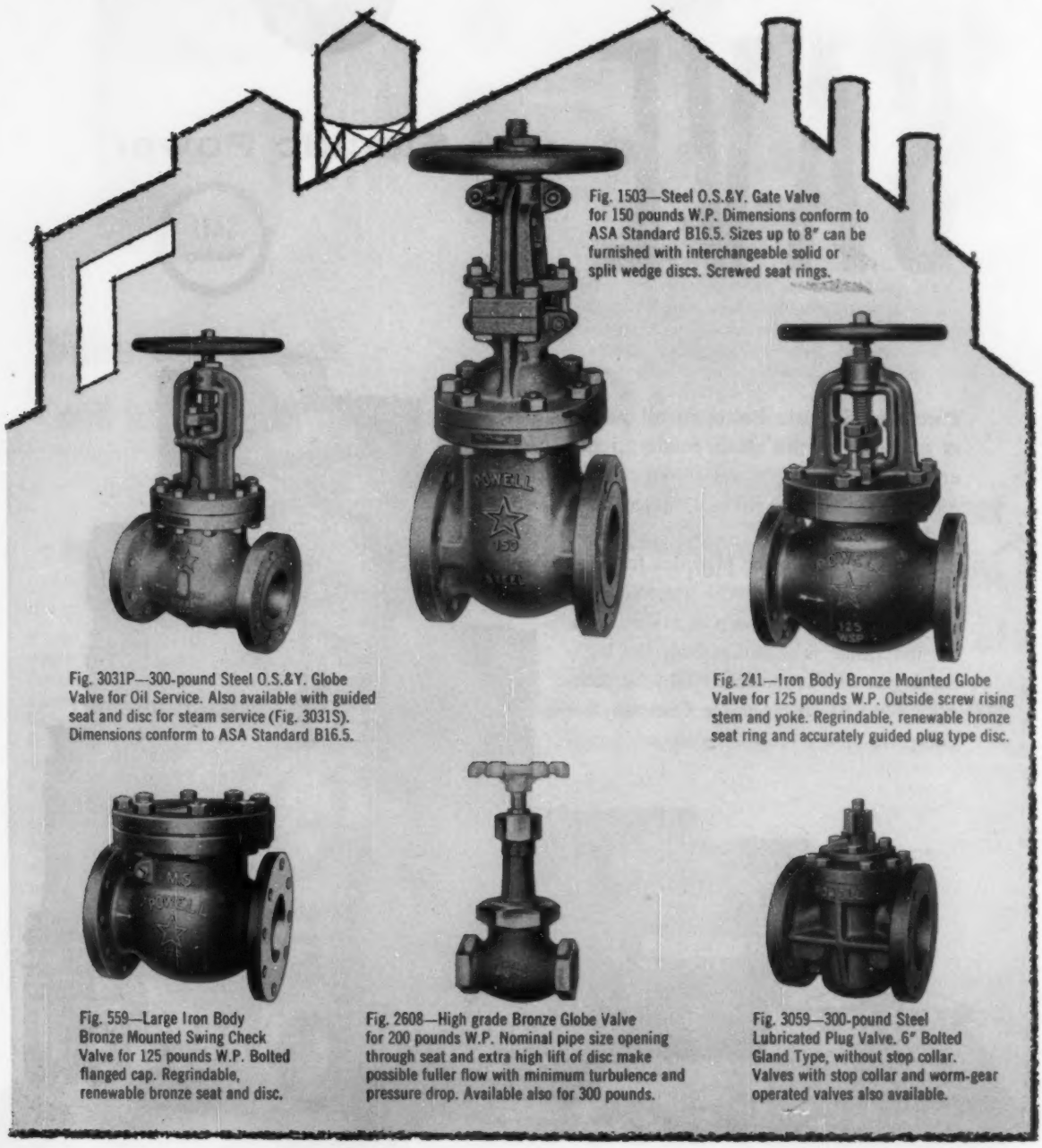


Fig. 1503—Steel O.S.&Y. Gate Valve for 150 pounds W.P. Dimensions conform to ASA Standard B16.5. Sizes up to 8" can be furnished with interchangeable solid or split wedge discs. Screwed seat rings.

Fig. 3031P—300-pound Steel O.S.&Y. Globe Valve for Oil Service. Also available with guided seat and disc for steam service (Fig. 3031S). Dimensions conform to ASA Standard B16.5.

Fig. 241—Iron Body Bronze Mounted Globe Valve for 125 pounds W.P. Outside screw rising stem and yoke. Regrindable, renewable bronze seat ring and accurately guided plug type disc.

Fig. 559—Large Iron Body Bronze Mounted Swing Check Valve for 125 pounds W.P. Bolted flanged cap. Regrindable, renewable bronze seat and disc.

Fig. 2608—High grade Bronze Globe Valve for 200 pounds W.P. Nominal pipe size opening through seat and extra high lift of disc make possible fuller flow with minimum turbulence and pressure drop. Available also for 300 pounds.

Fig. 3059—300-pound Steel Lubricated Plug Valve. 6" Bolted Gland Type, without stop collar. Valves with stop collar and worm-gear operated valves also available.

For every flow control problem Powell offers more kinds or types, available in the largest variety of metals and alloys to handle every flow control requirement. Powell distributors are located in all principal cities and maintain inventories to fill almost any need. For special engineering problems, write direct to:

THE WM. POWELL COMPANY • *Dependable Valves Since 1846* • **Cincinnati 22, Ohio**

For more data on advertised products, use Readers' Service Cards, last page.

MATCHLESS #5 STEAM HOSE

3 Men . . . 3 Applications
One Hose

Safety
U. S. Matchless #5 Steam Hose has been used at a Phillips Petroleum refinery* since 1930, for thawing and firefighting.

Easy Handling
Here U. S. Matchless #5 is being used to remove spilled oil.

Economy
Warehouse boss at Phillips Petroleum inspecting a length of U. S. Rubber Matchless #5 Steam Hose.

Men like to work with U. S. Matchless® #5 because it's so lightweight, so flexible. Ordinary hose is hard to handle, can't take much dragging around. But the hose that's readily available, lasts longer, and satisfies the operators is the best investment. That's U. S. Matchless.

When you think of rubber, think of your "U. S." Distributor. He's the best on-the-spot source of technical aid, quick delivery, and industrial rubber products.

*Okmulgee, Okla.

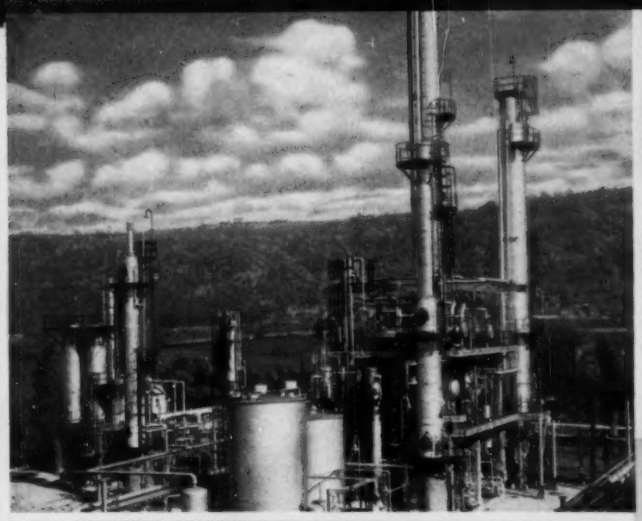
Mechanical Goods Division

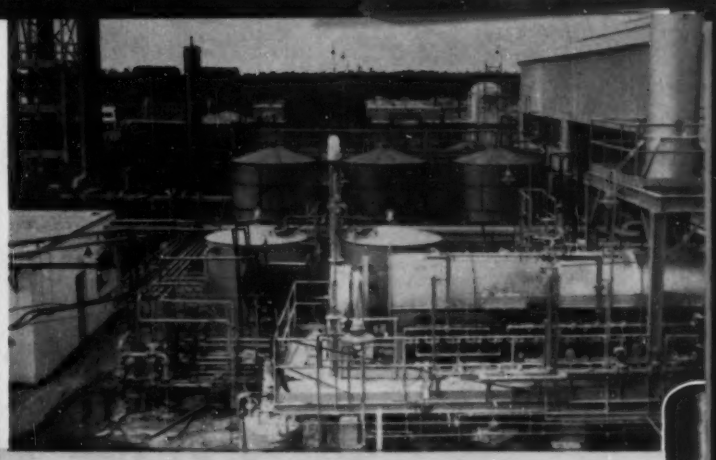
United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

For more data on advertised products, use Readers' Service Cards, last page.





They bring the "tough ones" to Badger

On these two pages are shown a few of the difficult projects successfully completed by Badger during the past year.

They were tough, but we did them. As a result of accomplishments like these, Badger's growth in '57 was double the previous year's.

Now, we think we have earned the right to an easy assignment. *You* have the right to think that if Badger can do the tough ones so well,

Badger can do the easy ones better, too

It's worth investigating — and easy. Key Man Service can be yours in a matter of hours — call or write today!

AIChE

1958—GOLDEN ANNIVERSARY

Congratulations from Badger on 50 years of achievement. All the Directors of Badger Manufacturing Company are Members of the Institute.

BADGER

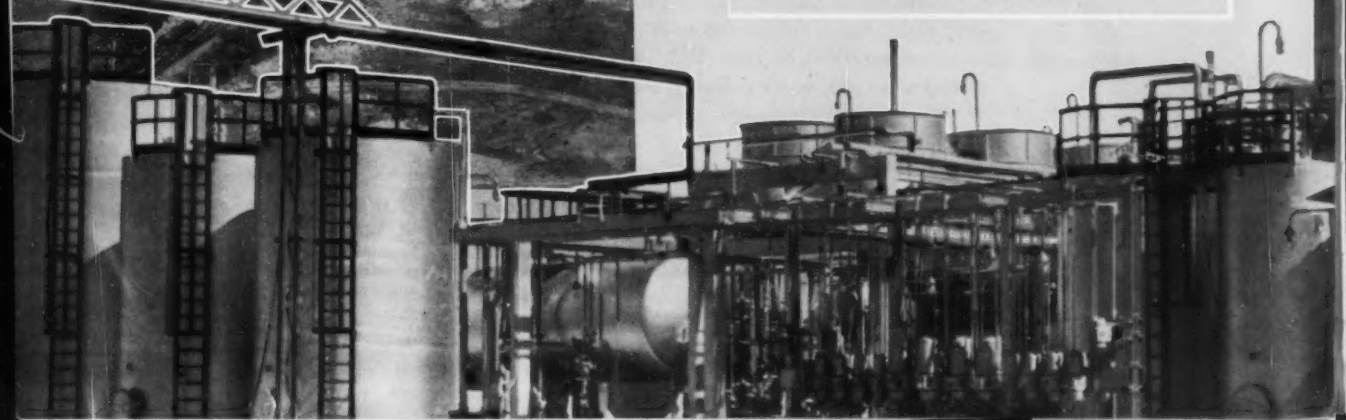
MANUFACTURING COMPANY

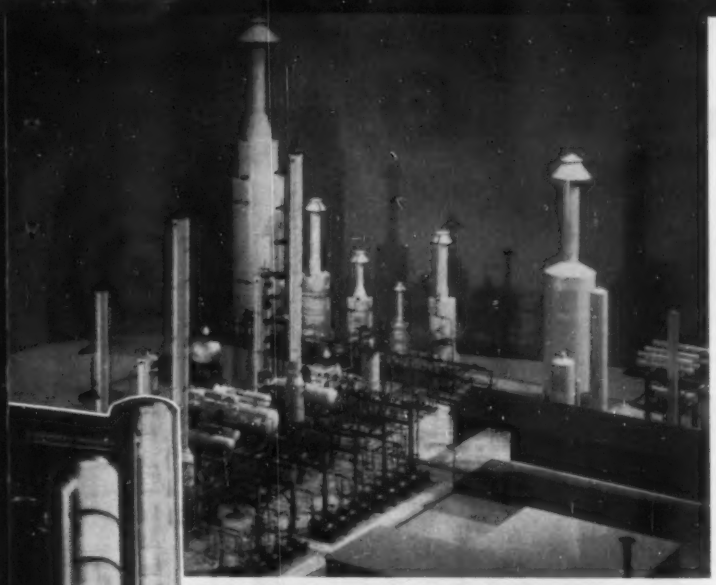
ENGINEERS • CONTRACTORS • DESIGNERS • MANUFACTURERS

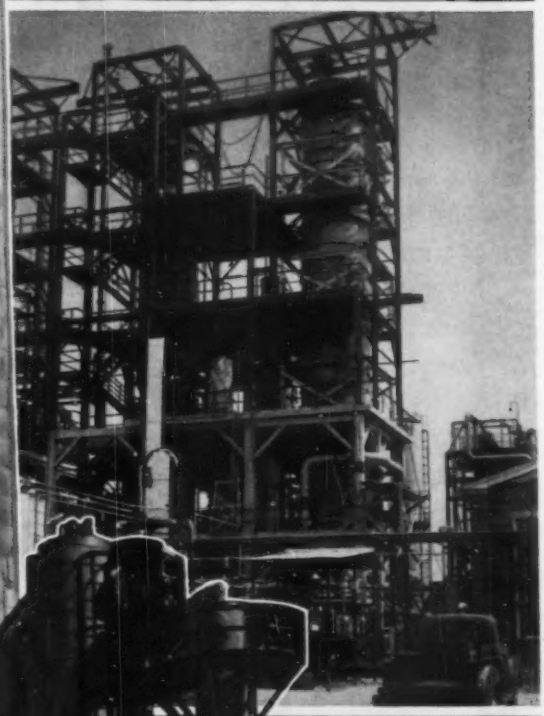
230 Bent St., Cambridge, Mass. • New York, N. Y. • Houston, Texas

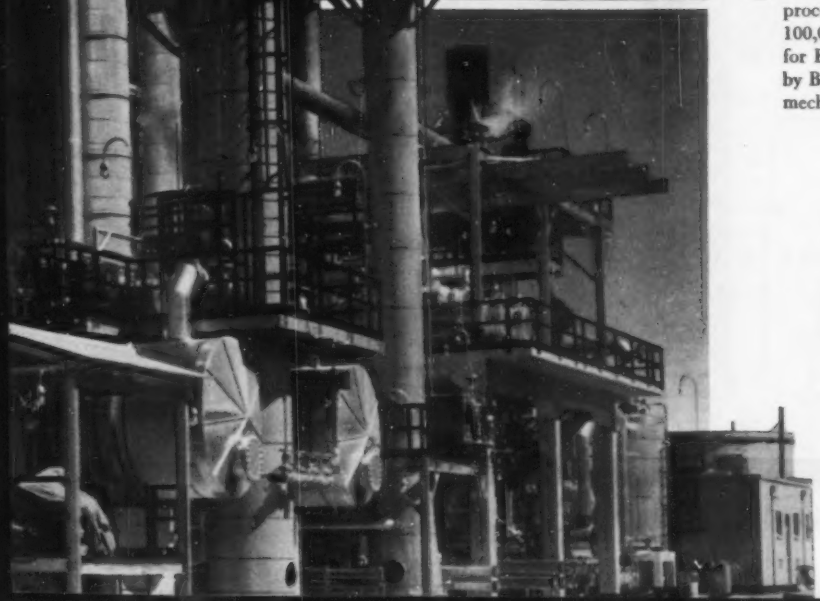
IN EUROPE: Badger-Comprimo N. V., The Hague

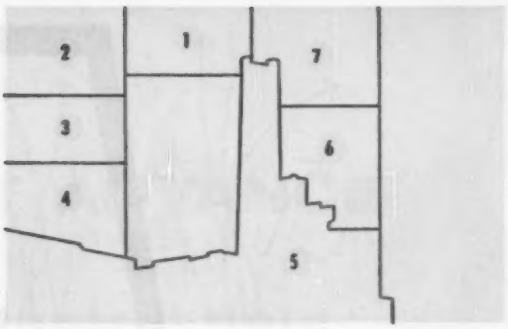
Badger-Comprimo S. A., Antwerp











1 **Columbia-National Corp., Pensacola, Fla.** This plant, engineered and constructed for Columbia-National Corporation, will produce 1,500,000 pounds of hafnium-free Zirconium per year.

2 **Jones & Laughlin Steel Corp., Aliquippa, Pa.** Revolution in coal chemicals! For Jones & Laughlin Steel Corporation Badger engineers came up with a new process application that eliminates the conventional acid-washing step to produce near absolute pure benzene and toluene.

3 **Esso Standard Oil Co., Everett, Mass.** One of three current Powerformer projects being handled by Badger. Unit shown is now producing Golden Esso Extra at Esso's Everett, Massachusetts, refinery. Plant was built completely on "stilts" — piles driven deep into tideland marshes.

4 **Metal Hydrides Inc., Danvers, Mass.** A new plant for the production of Sodium Borohydride, a component of "exotic" fuels. Badger handled the engineering, procurement and construction on this job. Plant was ready in record time even though the process was new and tricky.

5 **Cosden Petroleum Corp., Big Spring, Texas.** Styrene from gasoline! Ultra-fractionation and other pioneering process developments made this "impossible" plant a commercial reality. On stream in February 1957, the plant produced better than plastic-grade styrene right from initial start-up!

6 **Commercial Solvents Corp., Sterlington, La.** More methanol facilities. This unit is one of four built in recent years for Commercial Solvents Corporation. Like all methanol units designed by Badger, no chemical purification step is used, yet the product exceeds all present purity specifications.

7 **Esso Nederland N. V., Rotterdam, The Netherlands.** Model of two process units similar to those being installed in a complete 100,000 bpsd refinery, now under construction in Rotterdam for Esso Nederland N. V. Badger-Comprimo, owned jointly by Badger and Comprimo N. V., The Netherlands, is prime mechanical, engineering and construction contractor.

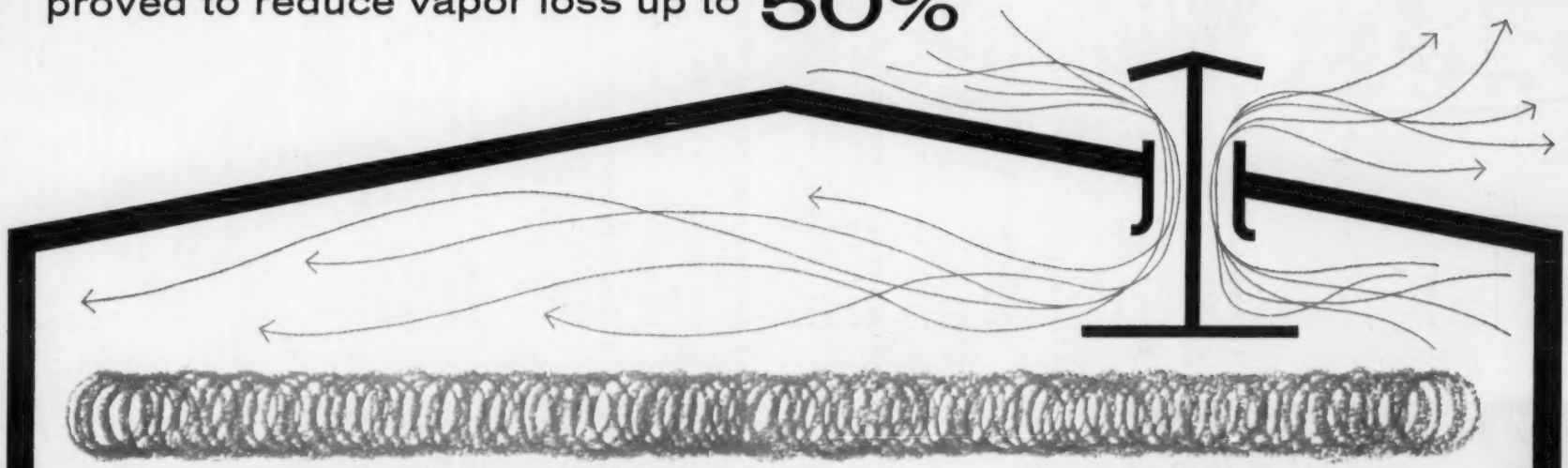
Other current Badger projects

Propane Deasphalting Unit — Anderson-Prichard Oil Corp., Arkansas City, Kansas • MEK Dewaxing-Deoiling Plant — Atlantic Refining Company, Point Breeze, Pa. • HF Alkylation Unit — Champlin Oil & Refining Company, Enid, Okla. • Sulfuric Acid Alkylation Unit — Chinese Petroleum Corporation, Taiwan, Formosa • Continuous Tar Distillation Plant* — Dominion Tar & Chemical Co., Ltd., Hamilton, Ontario • Powerforming Unit** — Esso Standard Refinery S. A., Antwerp, Belgium • Tall Oil Plant —The Glidden Company, Port St. Joe, Fla. • Benzene Udex Unit — Humble Oil & Refining Company, Baytown, Texas • Tall Oil Plant — Monsanto Chemical Company, Nitro, W. Va. • Methanol Plant — Rohm & Haas Company, Houston, Texas • MEK Dewaxing-Deoiling Plant — Sinclair Refining Company, East Chicago, Ind. • Vacuum Distillation Unit — Sinclair Refining Company, East Chicago, Ind. • Paraxylene Plant — Sinclair Refining Company, Houston, Texas • Xylene Udex Unit — Sinclair Refining Company, Houston, Texas.

Project of Canadian Badger Company Limited
***Project of Badger-Comprimo N.V., The Netherlands*

S&J AIR BAFFLE

proved to reduce vapor loss up to 50%



Downward velocity of air jetting into a tank through the breather vent causes currents which induce rapid product evaporation. S & J Air Baffle is a device which deflects incoming air into stratified layers above heavier, gas-rich air. The result is materially reduced surface boiling, with vapor losses cut from 25 to 50%. Unique Air Baffle design permits simple installation through the vent nozzle on tanks in service. Call or write for complete details and prices.

SHAND AND JURS

GPE GENERAL PRECISION EQUIPMENT CORPORATION

SHAND AND JURS COMPANY

2600 Eighth Street, Berkeley, California

A Subsidiary of General Precision Equipment Corporation
Branch offices and representatives in principal cities

4927

For more data on advertised products, use Readers' Service Cards, last page.

ANOTHER GREAT ADVANCE

in the automatic control field

due in late '58

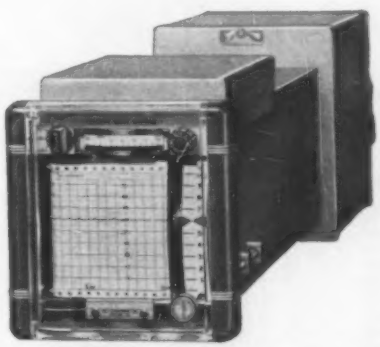
Swartwout has done it again.

In late '58, you'll be introduced to another new concept in the automatic control field. Swartwout has applied new thinking . . . a new principle to the solution of an old control problem.

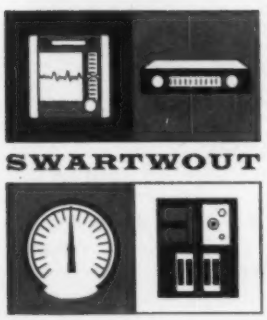
Swartwout is the pioneer and leader in the electronic process instrumentation field. The AutroniC Instrument line has demonstrated performance beyond any expectations. It has set new standards of simplified maintenance and complete flexibility. It has been proven in service and accepted by major segments of industry.

But this is not enough. Swartwout is determined to maintain its leadership position.

The new development is compatible with every Swartwout AutroniC Controller now in the field or that you now install. It's another step ahead for which you can be prepared . . . with AutroniC Instrumentation installed today.



TODAY with Swartwout AutroniC® Instrumentation, you are years ahead . . . stay ahead.



SWARTWOUT

. . . world leader in electronic process instrumentation

THE SWARTWOUT COMPANY
18511 EUCLID AVENUE,
CLEVELAND 12, OHIO

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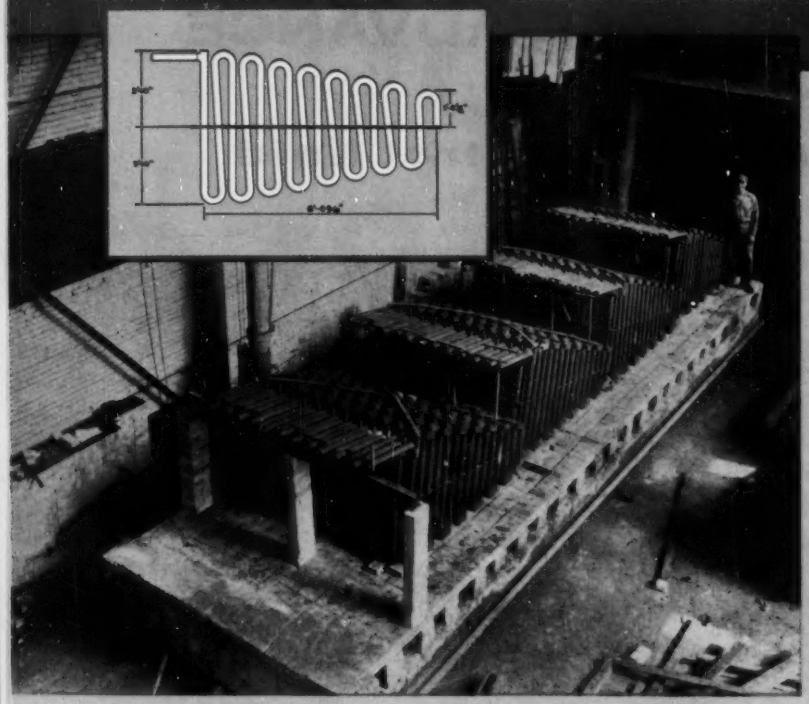
MIDWEST PIPE COILS

Meet the MOST EXACTING Specifications



FULL FURNACE ANNEAL

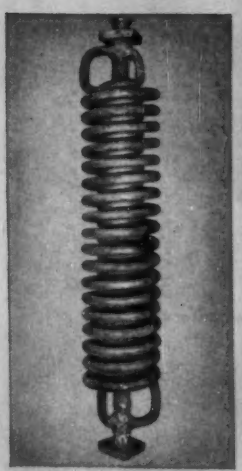
Furnaces of giant size enable us to anneal large coils under closely controlled conditions. Shown here is set of 48 kiln cooling coils 2⅜" OD x .165" wall bent on 6" centers with maximum reduction of ⅛" on OD. Material is 7% Cr—½% Mo.

Do you need coils

- . . . that are full furnace annealed
- . . . of intricate design
- . . . to comply with codes
- . . . with bends to close centers
- . . . to accurate dimensions
- . . . made of stainless steel or other corrosion resistant or heat resistant pipe?

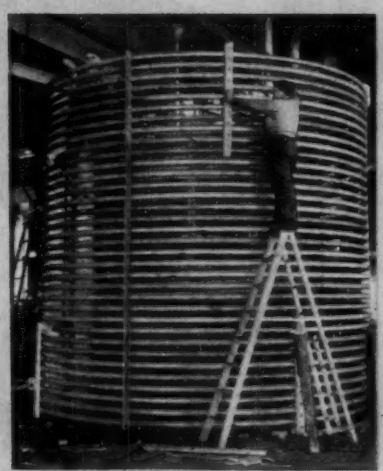
We make coils of any size, shape or contour . . . of any pipe which can be bent and welded. Equipment includes the most modern bending and coiling machines . . . furnaces large enough for full furnace anneal. Welding and coiling techniques are the most advanced, developed through long experience.

Here are just a few of the types of coils we make regularly. Send us your specifications.



DOUBLE COIL

Diameter of inside coil is only 8" while outside is 14". Made of 1¼" OD x 1⅛" ID 4-6% Cr—½% Mo tubing and full furnace annealed.



304 STAINLESS-SANITARY FINISH

Double cylindrical coil of 3" OD by 14 gauge, Type 304 stainless steel. All welds ground to sanitary finish.

KETTLE COIL

Made of 1" Schedule 40—316 ELC. Finished coil was heated to 1950°F and water quenched.

7677

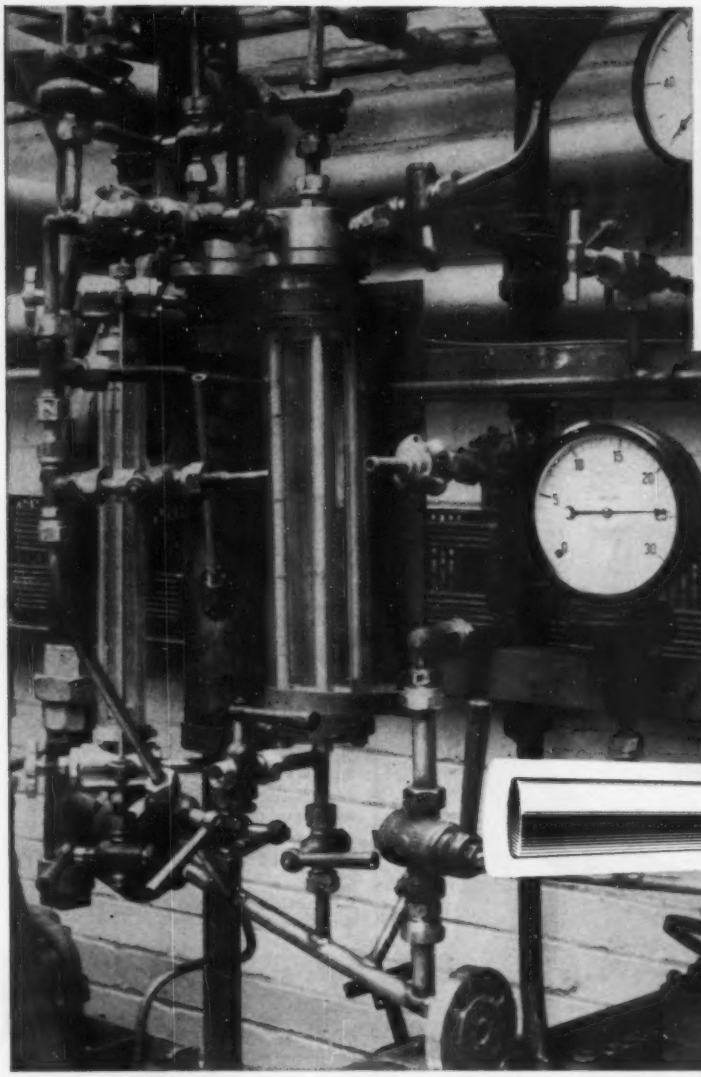
MIDWEST PIPING COMPANY, INC.

Main Office: St. Louis 3, Missouri (P. O. Box 443)

Plants: St. Louis, Clifton, N. J. and Los Angeles

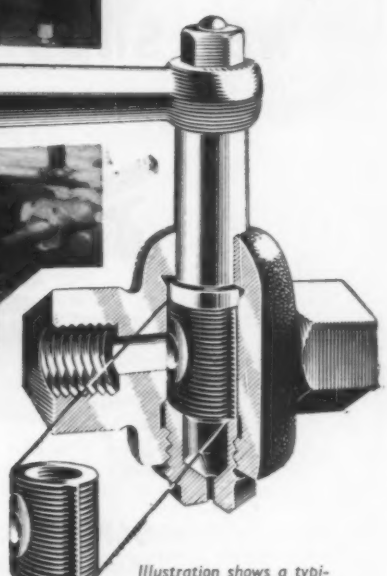
SALES OFFICES:

ASHEVILLE (BOX 446, SKYLAND, N.C.) • ATLANTA 9—72 ELEVENTH ST. N.E. • BOSTON 27—426 FIRST ST. • CHICAGO 3—79 WEST MONROE ST. • CLEVELAND 14—616 ST. CLAIR AVE. • HOUSTON 2—1213 CAPITOL AVE. • LOS ANGELES 33—520 ANDERSON ST. • MIAMI 34—2103 LE JEUNE RD. • NEW YORK 7—50 CHURCH ST. • PITTSBURGH 19, PA.—437 GRANT ST. • ST. LOUIS 4—1450 S. SECOND ST. • SAN FRANCISCO 11—420 MARKET ST. • TULSA—1640 E. 21ST. ST.



Klinger

SLEEVE-PACKED COCKS



In the last quarter of a century Klinger Sleeve-Packed Cocks have steadily replaced the old-fashioned asbestos-packed cocks with their limitations of working pressure, difficulty of repacking and tendency to jam. They are available in a wide range of designs and sizes for all purposes and pressures, and with the following advantages:

- **Renewable "Klingerit" packing sleeve.**
- **Re-tightening during use.**
- **Parallel-ground non-jam plug.**
- **Unobstructed straight-thru full-bore passage.**

Illustration shows a typical installation incorporating Klinger Sleeve-Packed Cocks, at a famous research establishment.

THE KLINGER CORPORATION OF AMERICA, 95 RIVER STREET, HOBOKEN, NEW JERSEY.
Telephone: Oldfield 6-1300

Manufacturing Licensees for Canada

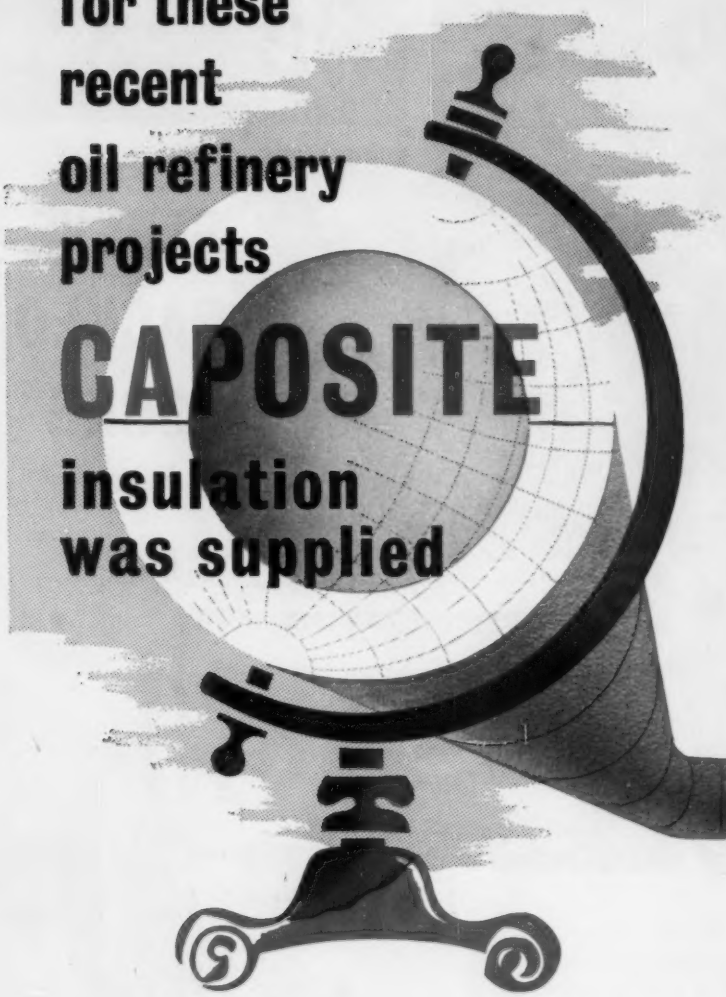
JOSEPH ROBB & COMPANY LIMITED, 5575, COTE ST. PAUL ROAD, MONTREAL, 20, CANADA
Telephone : GLENVIEW 9151
Branches at: SYDNEY, HALIFAX, OTTAWA, TORONTO, HAMILTON, WINNIPEG, EDMONTON, VANCOUVER, QUEBEC CITY

RICHARD KLINGER LIMITED, KLINGERIT WORKS, SIDCUP, KENT, ENGLAND.

GA42/58/C

For more data on advertised products, use Readers' Service Cards, last page.

for these recent oil refinery projects CAPOSITE insulation was supplied



BAHRAIN *at Awali*
for Bahrain Petroleum Co. Ltd.
Main Contractor: Foster Wheeler Ltd.

BURMA *at Syriam*
for The Burma Oil Co. (1954) Ltd.
Main Contractor: Foster Wheeler Ltd. (London)

CANADA *at Clarkson, Ontario*
for British American Oil Co. Ltd.
Main Contractor: The Lummus Co.

COLOMBIA *at Cartagena*
for International Petroleum Co. Ltd.
Main Contractor: Bechtel Corporation
(Insulation Contractor: Harold Aber & Co.)

ECUADOR *at La Libertad*
for the Anglo-Ecuadorian Oil Co. Ltd.
Main Contractor: Procon (G.B.) Ltd.

ENGLAND *at Kent Oil Refinery*
for The British Petroleum Co. Ltd.

FRANCE *at Raffinerie de Normandie*
for Compagnie Francais de Raffinage.
Main Contractors: Kellogg International Corporation and Foster Wheeler Ltd. (France).
(Insulation Contractor: Soc: Technisol).

IRAQ *at Daura, near Baghdad*
for Iraq Government Oil Refinery Administration.
Main Contractor: Foster Wheeler Ltd. (London).

ITALY *at Genoa*
for Raffineria Dottore E. Garrone.
Main Contractor: C.T.I.P.

KUWAIT *at Akmadi*
for the Kuwait Oil Co. Ltd.
Main Contractors: Bechtel-Wimpey and E. B. Badger & Sons Ltd.

THE NETHERLANDS *at Pernis*
for N. V. de Bataafsche Petroleum Maatschappij.

NETHERLANDS ANTILLES
at C.P.I.M. Refinery, Curacao
for Royal Dutch-Shell Group.

SCOTLAND *at Grangemouth*
for British Hydrocarbon Chemical Co. Ltd.
Main Contractor: E. B. Badger & Sons Ltd.

VENEZUELA *at Maracaibo*
for The Richmond Exploration Co.
Main Contractor: The Lummus Co.

CAPOSITE regd.

Amosite Asbestos Blocks and Pipe Sections

Speedy application .... long-lasting protection .... resilience to withstand rough handling .... long fibred Amosite asbestos, giving superior insulating properties — these are the reasons why CAPOSITE is being specified for more and more of today's refineries.

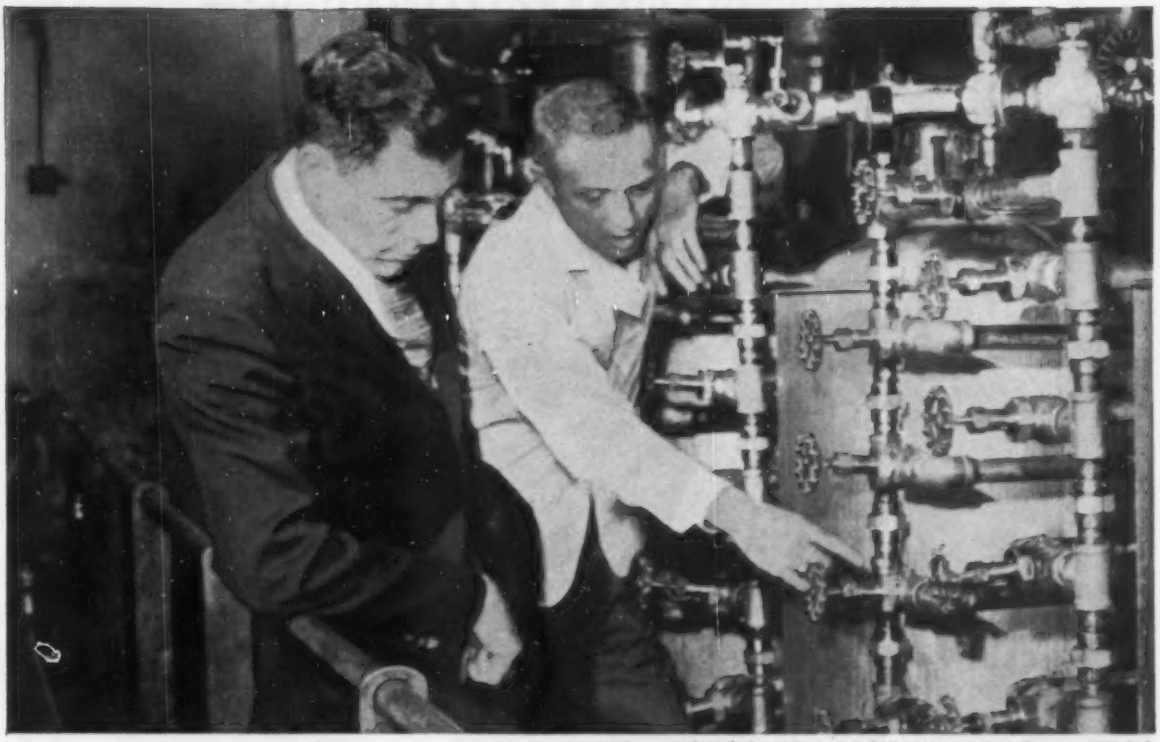
CAPOSITE *is also manufactured in*
SOUTH AFRICA, ITALY, CANADA, FRANCE, HOLLAND, SPAIN

THE CAPE ASBESTOS COMPANY LTD
114 & 116 PARK STREET, LONDON, W.1
Tel: GROsvenor 6022 Cables: Incorrupt London

Enquiries in Canada to:
Cape Asbestos (Canada) Ltd., 200 Bloor Street East, Toronto, Ont.
U.S.A. to: North American Asbestos Corpn., Board of Trade Building, Chicago, 4, Illinois

CAPE

TA 415



Joseph Smindak (right), Plant Engineer, Coffee Instants, Inc., Flushing, N.Y. Left, Michael De Piano, N.Y. representative, Cooper Alloy Corp. Foreground, Cooper Alloy 1" stainless Union Bonnet Globe Valves.

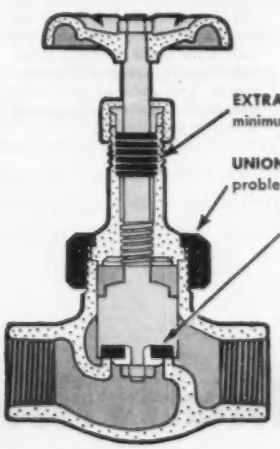
SMINDAK of COFFEE INSTANTS, INC.

Tells why he specifies Cooper Alloy for stainless steel valves and fittings

Q. Mr. Smindak, why does Coffee Instants, one of the nation's leading instant coffee processors, use stainless valves and fittings in processing their product?
A. To protect product purity, a must with us as with most other food processors. Contact with other metals can degrade flavor and aroma; stainless steel does not.

Q. Why Cooper Alloy?
A. Because of the special Cooper Alloy construction features I find combined in no other brand. On these Cooper Alloy union bonnet globe valves, for example, we like the ease of operation and the low maintenance; the fact that it removes a threaded joint from product contact; and in particular, the extra-deep square-compression stuffing box which reduces maintenance, gives a tighter seal at stem. Then too, the excellent service we get from Cooper Alloy sales people and distributors.

Q. You don't find these features in any competing valve?
A. Frankly, not one has them all. That's why, for our stainless valves *and fittings*, we insist on Cooper Alloy.


EXTRA-DEEP STUFFING BOX holds minimum 6 turns Blue African asbestos
UNION BONNET JOINT eliminates problems found in screwed-in bonnets
RETAINED RENEWABLE DISC for tight seal and long life

COOPER ALLOY Figure 15RD Globe Valve, inside screw rising stem, 200-lb. service, screwed ends, renewable retained disc of composition you specify.

YEARS AHEAD IN DESIGN SUPERIORITY! No matter what your valve type—globes, gates, angles, checks, or Y's—the Cooper Alloy model's outstanding design features will be important to you. Cooper Alloy, with 35 years of pioneering experience in stainless steel, does not merely adapt existing brass and iron valve patterns; it creates valves *designed to be cast in stainless!* **Check the special design features of valve shown at left.**

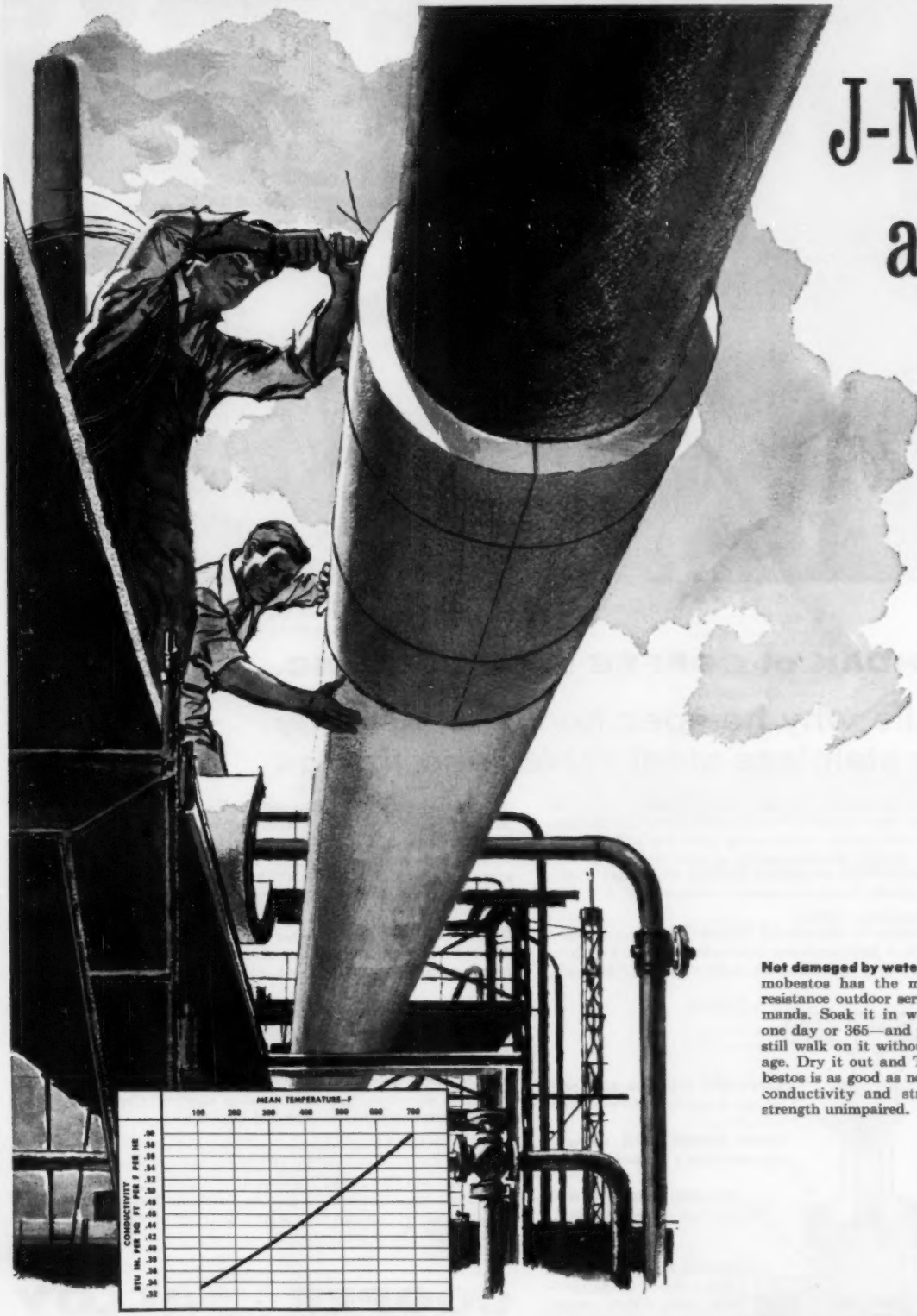
As the little CA man below is saying: "*You Can Tell A Cooper Alloy Valve As Far As You Can See It!*" Write today for *your* copy of our folder "Design Factors In Stainless Steel Valves." The Cooper Alloy distributor near you will be glad to show you the complete line of Cooper Alloy valves *and fittings*, and their advantages. He can serve you promptly from local stocks.

COOPER ALLOY
Corporation • Hillside, New Jersey
VALVE & FITTING DIVISION
THIRTY-FIVE YEARS OF STAINLESS STEEL PIONEERING

For more data on advertised products, use Readers' Service Cards, last page.

In developing THERMOBESTOS Insulation

J-M at



Not damaged by water. Thermobestos has the moisture resistance outdoor service demands. Soak it in water for one day or 365—and you can still walk on it without damage. Dry it out and Thermobestos is as good as new, with conductivity and structural strength unimpaired.

Low Conductivity. The low thermal conductivity of Thermobestos is best demonstrated in actual service where it makes possible accurate, uniform temperature control, helps reduce fuel costs and contributes materially to operating efficiency.

Johns-Manville

For more data on advertised products, use Readers' Service Cards, last page.

for outdoor process industry applications

research scientists didn't stop top insulating effectiveness...

They added the three physical properties you most wanted— HIGH STRENGTH—LIGHT WEIGHT —MOISTURE RESISTANCE!

Thermobestos® offers the lowest k factor of all insulations in general use throughout the process industries. For maximum heat control on outdoor piping and equipment operating at temperatures to 1200F it just can't be beat!

Yet top insulating effectiveness is only one reason why more and more engineers are specifying Thermobestos for refineries, chemical plants, and wherever hot outdoor vessels and piping must be insulated. For Thermobestos also offers a threefold bonus . . .

. . . Three outstanding physical properties

Thermobestos is 1) strong and rigid. Its hard composition resists crushing and easily withstands unusual service abuse. Yet it is 2) lightweight for easy handling and fast application. And it is 3) highly moisture resistant, remains undamaged even by prolonged wetting.

Quickly, easily applied

Thermobestos is made from hydrous calcium silicate . . . molded to size for proper fit. Its high strength makes it particularly adaptable for time-saving shop prefabrication of fittings and bends.

Furnished in large sections, Thermobestos is easy to apply. It reduces the number of joints. In pipe insulation form, it comes in a complete selection of sizes up to 30″ O. D. Also available in 6″ x 36″ and 12″ x 36″ blocks in a full range of thicknesses.

For further information write for your free copy of the 12-page Thermobestos booklet, IN-169A. Address Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

INSULATIONS FOR LASTING THERMAL EFFICIENCY
MATERIALS · ENGINEERING · APPLICATION

JOHNS-MANVILLE JM PRODUCTS

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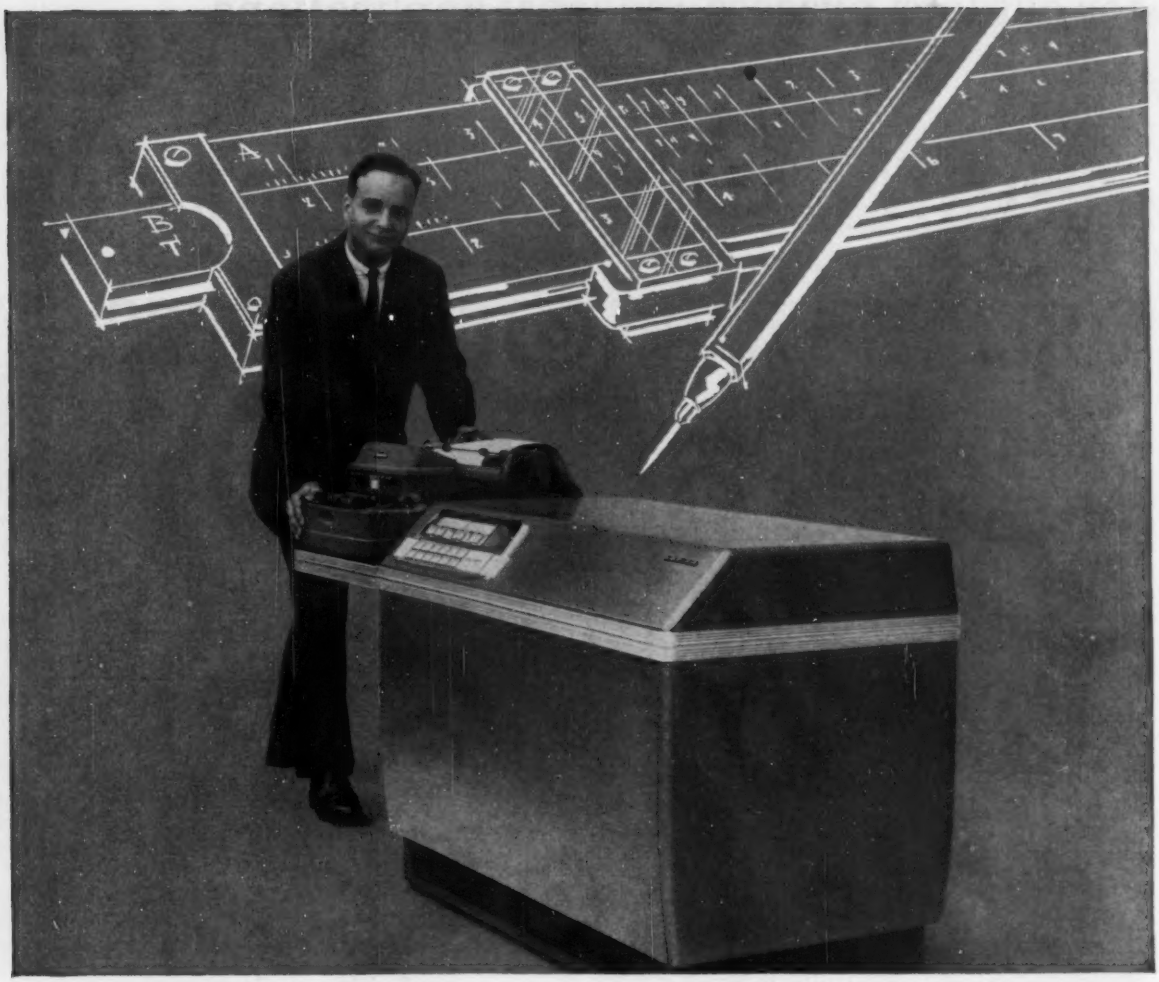

Now! On-site linear programming at high speed with this powerful electronic computer

ROYAL PRECISION LGP-30

Here's the mobile, stored-program electronic computer with large capacity...direct print-out of answers

Compact, completely mobile . . . Royal Precision LGP-30 will today furnish you with high-speed electronic computation *wherever you want it* – give you more time for *creative* engineering. And at the lowest cost ever for a complete computer system!

Unusual capacity. Operating from any convenient wall outlet, the self-cooled LGP-30 allows you to work your linear programming *on site*. Used *right at your desk* for any other problem, LGP-30 gives you the greater flexibility of stored-program operation...speed, memory (4096 words) and capacity comparable to equipment many times its size and cost. (In one application, for instance, LGP-30 handled a linear program with as large a matrix as 46 x 27.) Answers are printed out directly in a format which requires no deciphering.

Simple to operate and program. LGP-30's controls are so simplified, even non-technical personnel are quickly trained. Programming is easily learned. A library of sub-routines, plus programs for a wide variety of applications, are available.

Wide scope of petroleum applications. Among the jobs for which LGP-30 is now being widely used in the petroleum industry are: pipeline problems, mass spectrometer problems, analysis of oil field production, flash point calculations, pumping and batching scheduling, correlation of seismic records, reservoir engineering studies and well-logging interpretations.

Exceptional value; complete service. Smallest initial investment ever for a complete computer is combined with low operating and maintenance costs. Service facilities are available coast-to-coast.

For further information and specifications, write Royal McBee Corporation, Data Processing Equipment Division, Port Chester, N. Y.

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WORLD'S LARGEST MANUFACTURER OF TYPEWRITERS
AND MAKERS OF DATA PROCESSING EQUIPMENT

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SOLVAY CAUSTIC SODA

. . . and all include Solvay extra services

To help you use SOLVAY Caustic Soda most *efficiently*, we make 9 forms. To supply it *rapidly* and *dependably*, we produce it in 5 widely-scattered plants. To aid you in applying it most *effectively*, we provide technical service and literature based on extensive field work with users and painstaking laboratory research.

Sodium Nitrite • Calcium Chloride • Chlorine • Caustic Soda • Caustic Potash Chloroform • Potassium Carbonate • Sodium Bicarbonate • Vinyl Chloride • Methyl Chloride • Ammonium Chloride • Methylene Chloride • Monochlorobenzene Soda Ash • Para-dichlorobenzene • Ortho-dichlorobenzene • Carbon Tetrachloride Ammonium Bicarbonate • Snowflake® Crystals • Aluminum Chloride • Cleaning Compounds • Hydrogen Peroxide • Mutual Chromium Chemicals

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61 Broadway, New York 6, N. Y.

Please send without cost SOLVAY Caustic Soda sample or samples and literature as follows:

☐ 76% powdered ☐ 76% solid ☐ 76% ground ☐ 76% flake
☐ 76% small flake ☐ 50% liquor ☐ 73% liquor ☐ 50% mercury cell liquor ☐ 73% mercury cell liquor
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of temperatures with
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CALTEMP
a Calcium Silicate
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Temperature	Recommended Pabco Insulation
to 550° F.	85% Magnesia pipe covering • block • cement
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to 1500° F.	Prasco 15 C pipe covering • block • cement
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Name your temperature. A performance-proved Pabco pipe or block insulation will maintain it at economical levels up to 1900° F. With Pabco Caltemp, 85% Magnesia, or Prasco Insulations, heat losses are reduced to an absolute minimum . . . finest performance assured. For data on technical advantages, case histories, or engineering consultation . . . write . . . or contact one of Pabco's insulation engineers.

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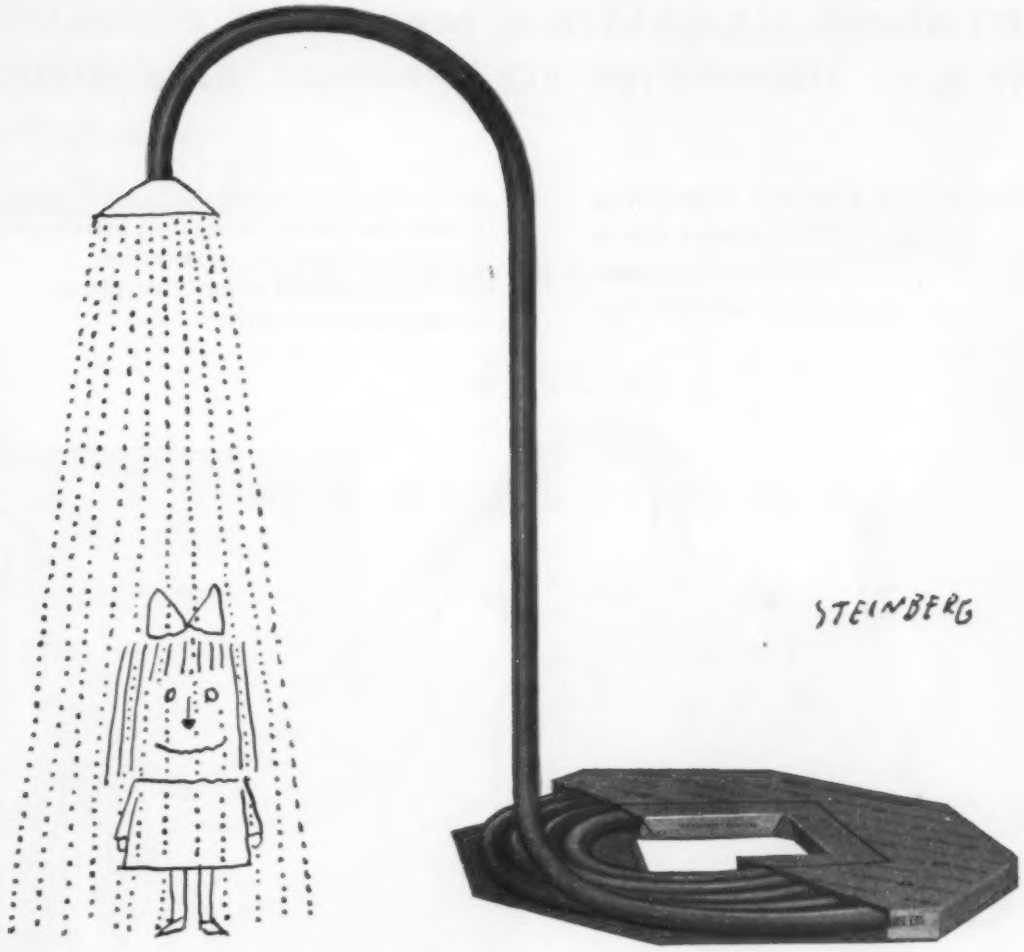

How to keep the Fountain of Youth from Aging...

fastidious

Lewin-Mathes Seamless Copper Tube and Pipe showers its benefits in a pure, steady stream on a little girl. And decades later, it will show equal regard for her grandchild.

Through the years, the Lewin-Mathes installation performs like new without maintenance because—as Copper Tube *Specialists*—we build Copper's resistance to everything except flow. Lewin-Mathes' fastidious-minded inspectors — at every operation throughout our *completely integrated plant*—demand shiny smooth surfaces *inside* as well as outside our products.

When installing piping materials, be sure that your *first* cost is your *last* cost. Ask your architect, designer or engineer to specify Lewin-Mathes.

LEWIN (LM) MATHES

SAINT LOUIS, MISSOURI

COPPER AND BRASS TUBE PIPE AND ROD

DIVISION OF CERRO DE PASCO CORP.

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TRETOLITE DESALTING MAKES IT POSSIBLE FOR ANY REFINERY TO CHARGE ANY CRUDE

when you specify desalting, remember these facts about Tretolite chemical desalting:

1. 98 to 100% salt removal.
2. Lowest per barrel throughput installation cost.
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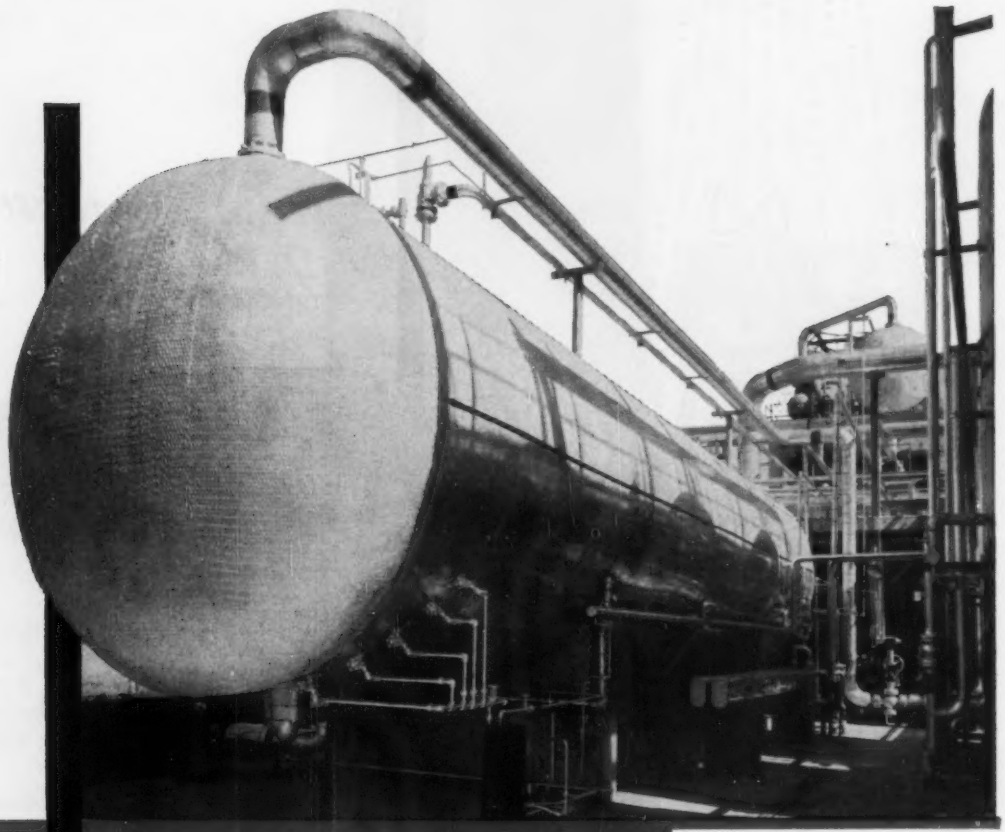

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Complete facilities for the production of the finest heat exchangers are at your service at Yuba. With branch offices and representatives at every principal point throughout the country, Yuba is able to have a sales-engineer at your desk in a matter of hours to help you start your heat exchanger project.

At three of Yuba's plants at Honesdale, Pa., Buffalo, N. Y., and Richmond, Calif., are top heat exchanger engineers with national reputations for their progressive designs. Daily they design all types of heat exchangers, large or small, simple or complex... heat exchangers which operate at vacuum or to pressures of 5000 psi, at temperatures below zero or to 1000 F and higher . . . heat exchangers made of all kinds of metals: carbon steel, alloy steel, aluminum, nickel, and non-ferrous alloys such as the new silicon bronzes... heat exchangers with bundles having a few tubes or as many as 7500, with heat transfer surfaces up to 15,000 and 20,000 sq. ft.

Yuba is experienced... some of its divisions having made heat exchangers for as long as 50 years. Yuba has outstanding techniques... many of its heat exchangers having been "firsts" in their fields. Yuba is nationally recognized... in the chemical, oil, gas, power, mechanical and heating industries.

Buy Yuba. Its plants in both the East and the West mean convenience for you, speedy delivery, service . . . but, above all, well-engineered heat exchangers tailor-made for your own process.

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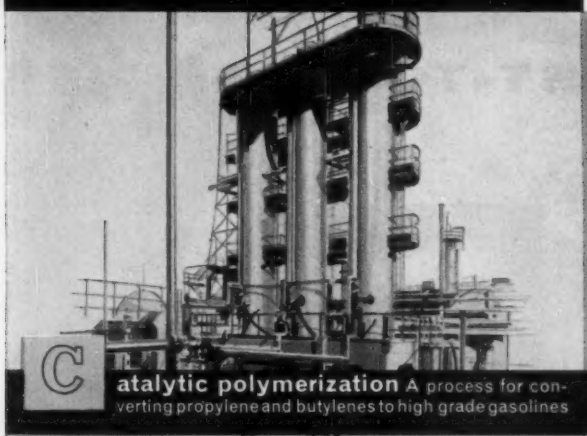
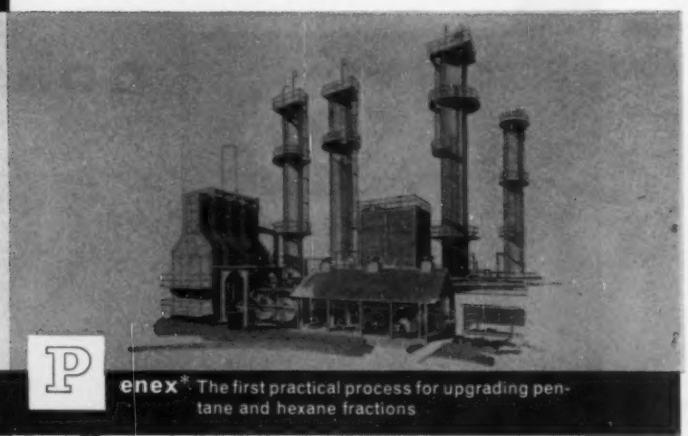
answer to most every petroleum processing problem.

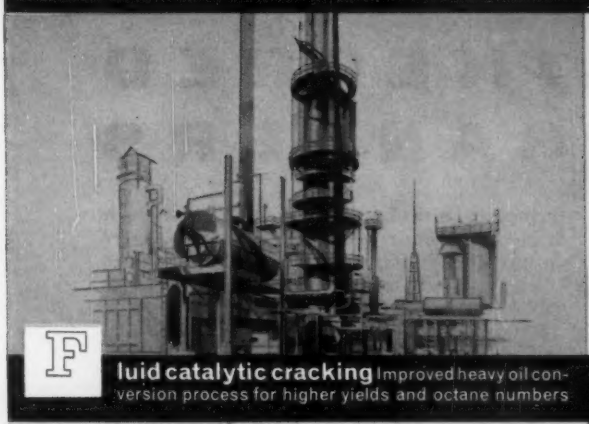
Working out the solution to a processing problem can be a pretty tough assignment for any refiner. But this is a UOP specialty and it's highly probable that UOP can come up with the right answer. Perhaps, we don't have all the answers right on tap but our more than 40 years of research and engineering development in oil refining technology is pretty good assurance that we can work them out. Quite possibly you will find



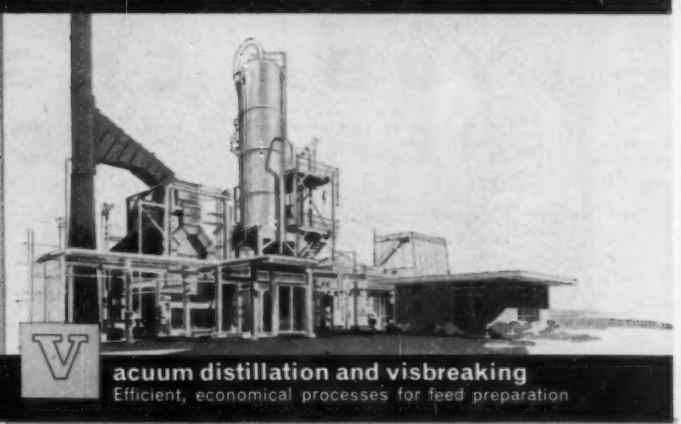
Catalytic polymerization A process for converting propylene and butylenes to high grade gasolines



Penex®. The first practical process for upgrading pentane and hexane fractions

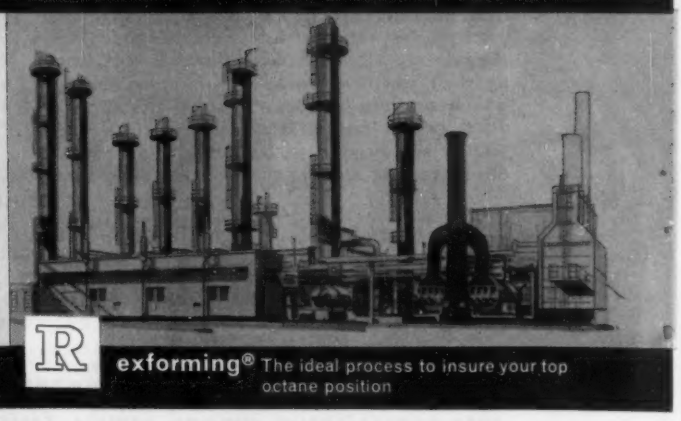


Fluid catalytic cracking Improved heavy oil conversion process for higher yields and octane numbers



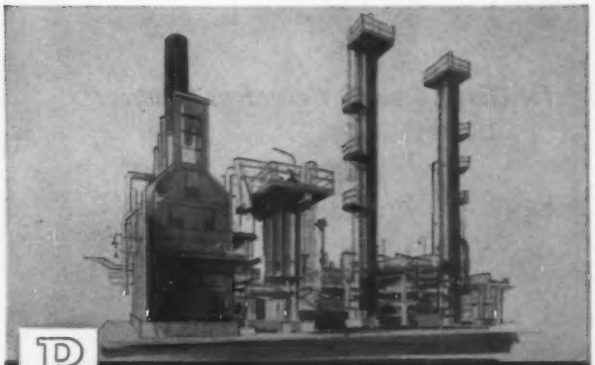
Vacuum distillation and visbreaking Efficient, economical processes for feed preparation

Low pressure coking A process that adds market flexibility

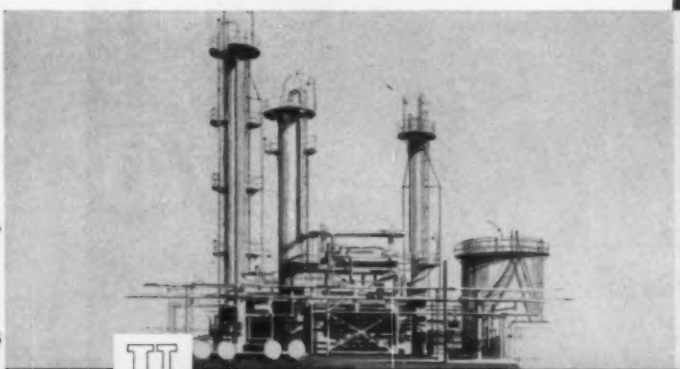


Rexforming® The ideal process to insure your top octane position

the solution among the processes shown here. For these represent only some of the refining and petrochemical processes UOP makes available to all refiners, anywhere. If you would like to know more about all the refining and petrochemical processes available from UOP we'll be glad to send you our handsome new 36 page brochure describing these more fully. Just drop us a line on your company letterhead.

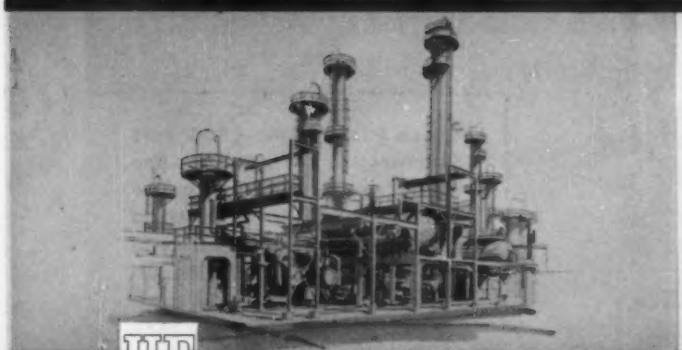


P latforming® The most popular process for upgrading gasolines



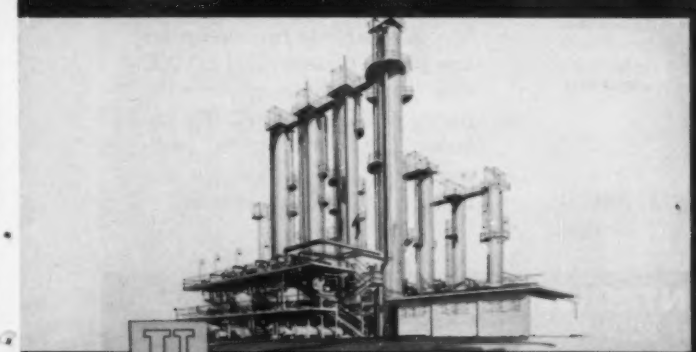
U nisol® A finishing process without octane degradation

U nifining® A modern process for completely purifying petroleum distillates



HF Alkylation A catalytic process for producing alkylate

T hermal cracking An improved design of a basic refining process



U dex® A process for separating gasoline into high and low octane fractions

UOP® UNIVERSAL OIL PRODUCTS COMPANY

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Des Plaines, Illinois, U.S.A.

MORE THAN FORTY YEARS OF LEADERSHIP IN PETROLEUM REFINING TECHNOLOGY

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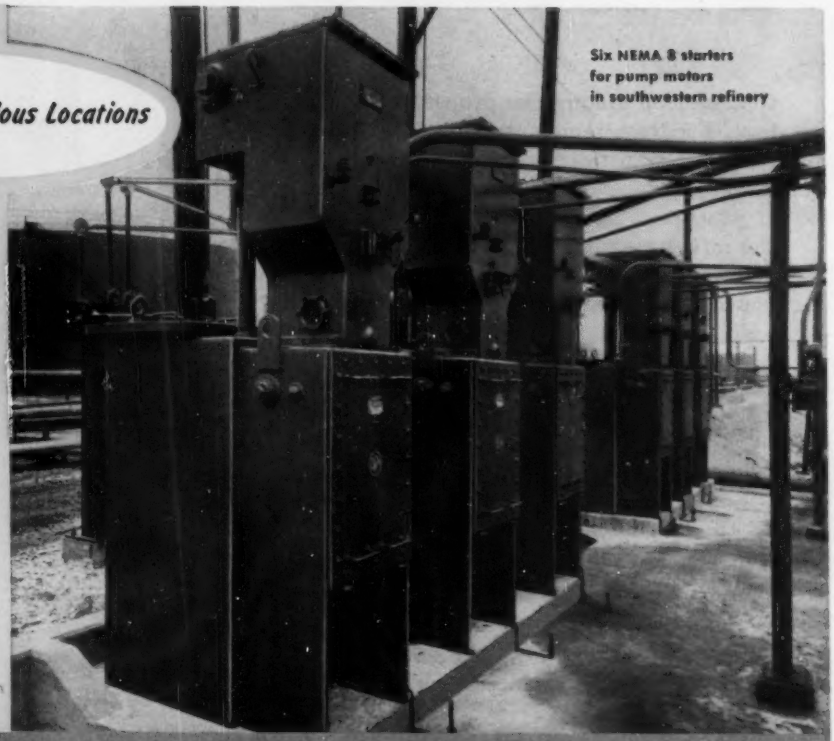
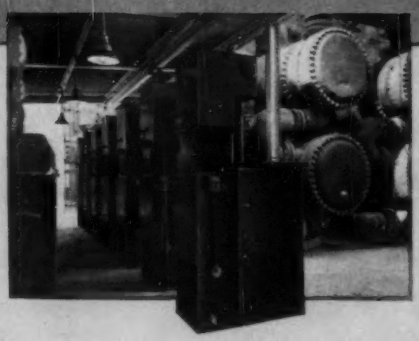


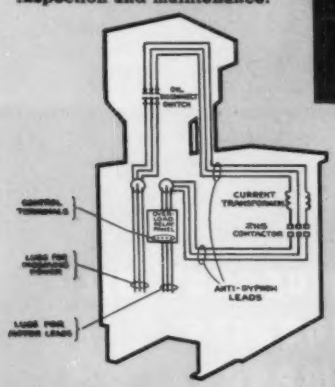
Six NEMA 8 starters for pump motors in southwestern refinery

here's how to

SAVE SPACE and INSTALLATION TIME with EC&M HIGH VOLTAGE STARTERS

SPACE SAVERS! Each of the seven starters in the eastern refinery installation *(at the right)* requires a space of only 2 ft. x 4 ft.—permitting close grouping with maximum accessibility for inspection and maintenance.





YOU SAVE INSTALLATION TIME because every EC&M starter is shipped with all internal wiring complete. *(See diagram at left)* All leads are of anti-syphon construction.

Write for Bulletin 8131 AM

These EC&M 2200-4800 volt Starters are designed for use where hazardous mixtures of air and inflammable gases or vapors are ever-present. NEMA 3R (raintight) enclosure permits mounting indoors, outdoors, or in semi-enclosed location. Load-break oil disconnect switch is self-contained and completely wired into the starter.

Available in two ratings for any power capacity. (*1*) 50,000 KVA (certified) interrupting capacity of EC&M Type ZHS Contactor. (*2*) In VALIMITOR® (volt-ampere-limitor) style... the bus may be of unlimited capacity.

THE ELECTRIC CONTROLLER & MFG. CO.
A DIVISION OF THE SQUARE D COMPANY
CLEVELAND 28 • OHIO

7936

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ALUMINUM GATE VALVES

by Darling

Darling gate valves of aluminum alloy offer all of the unique, extended-life features inherent with the Darling fully revolving double disc, parallel seat principle... for performance that assures unmatched economy... and freedom from leakage, trouble and downtime!

These Darling aluminum alloy valves are now available in ½" through 24" sizes. Write for full details, specifying your particular service requirements.

DARLING VALVE & MANUFACTURING CO.

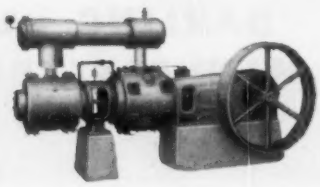
WILLIAMSPORT 31, PA.

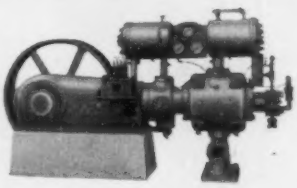
The class T compressor is one of a complete line of CP compressors for process work. Other types available in sizes to 5,000 HP for pressures to 15,000 psig, with motor, steam or belt drive.

Chicago Pneumatic 8 East 44th Street, New York 17, N. Y.

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC TOOLS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS

Two-stage class TCB-2 compressor for pressures up to 500 lbs.



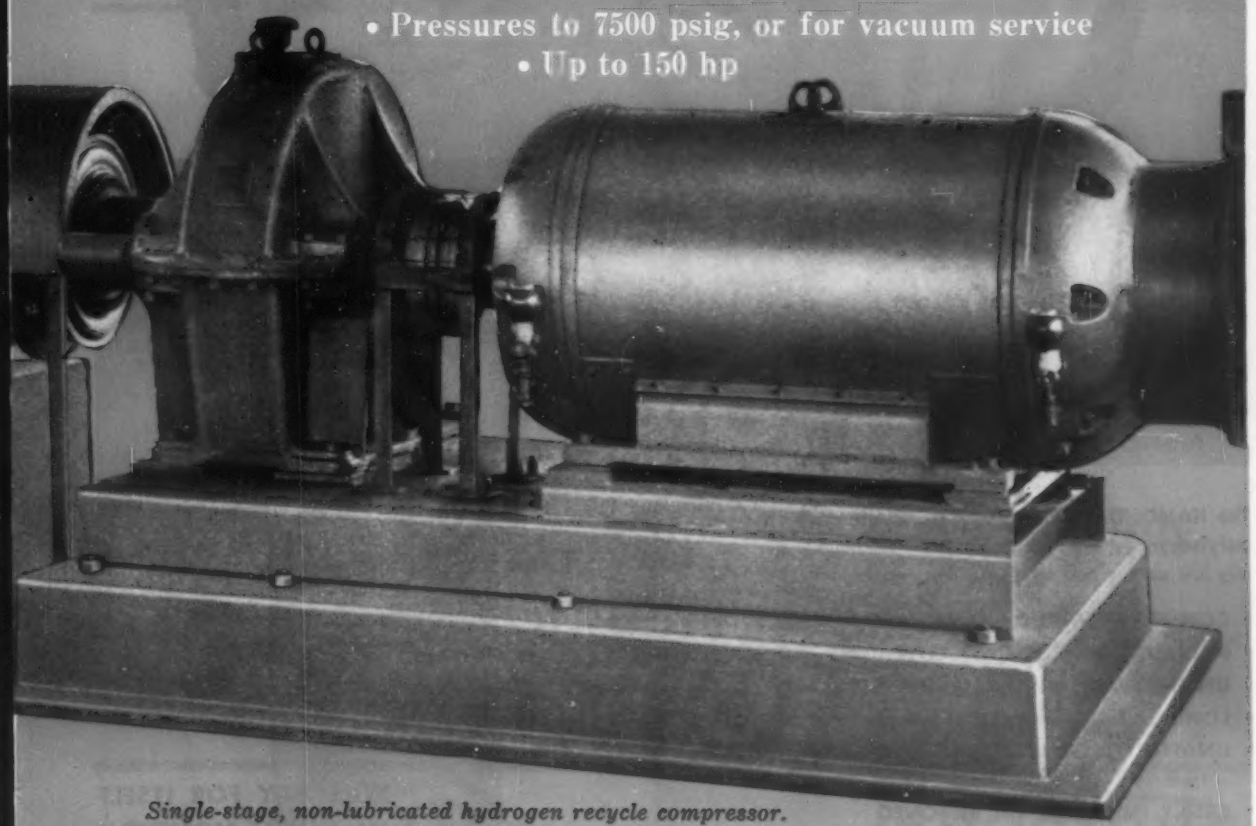


Typical three-stage class T compressor for pressures up to 2,500 lbs.

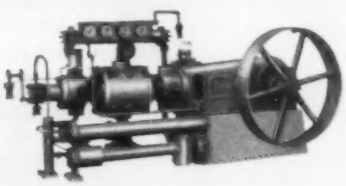
Class T

PROCESS COMPRESSORS

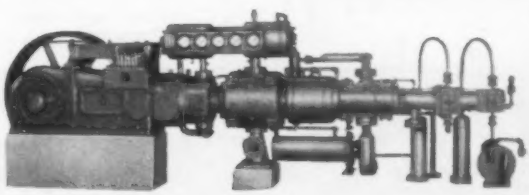
- Pressures to 7500 psig, or for vacuum service
- Up to 150 hp



Single-stage, non-lubricated hydrogen recycle compressor.



TCB-4 four-stage, straight-line compressor suitable for 6,000 lbs. discharge pressure.



Five-stage compressor designed for 7,500 lbs. service.

For more data on advertised products, use Readers' Service Cards, last page.

HAMMOND IRON WORKS

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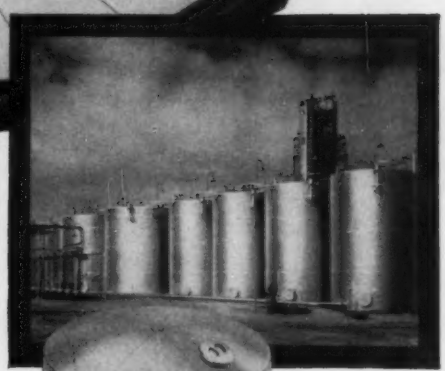
THE HAMONDFLOTE* plastic COVER

the first practical and guaranteed

FLOATING ROOF

HAMONDFLOTE COVER



FOR small diameter tanks in MARKETING, BULK STORAGE, PRODUCING and REFINING OPERATIONS.

Suitable for storing gasolines, crude oils, and hydrocarbon chemicals.

The HAMONDFLOTE COVER is constructed of rigid polyisocynate foam—a plastic material with exceptionally low density and high load carrying capacity.

- **CONSERVES VAPOR • PRESERVES PRODUCT**
- **PREVENTS CORROSION • LOW COST—NO MAINTENANCE**
- **UNSINKABLE • VIRTUALLY INDESTRUCTIBLE**
- **LONG LIFE**—(more than 10 years expectancy)
- **UNAFFECTED BY WORKING TEMPERATURES** —(from —94° to +300° F)
- **EASILY INSTALLED OR REMOVED**

WILL PAY FOR ITSELF IN A FEW MONTHS.

Write or call us and we will send our nearest representative to give you full information.

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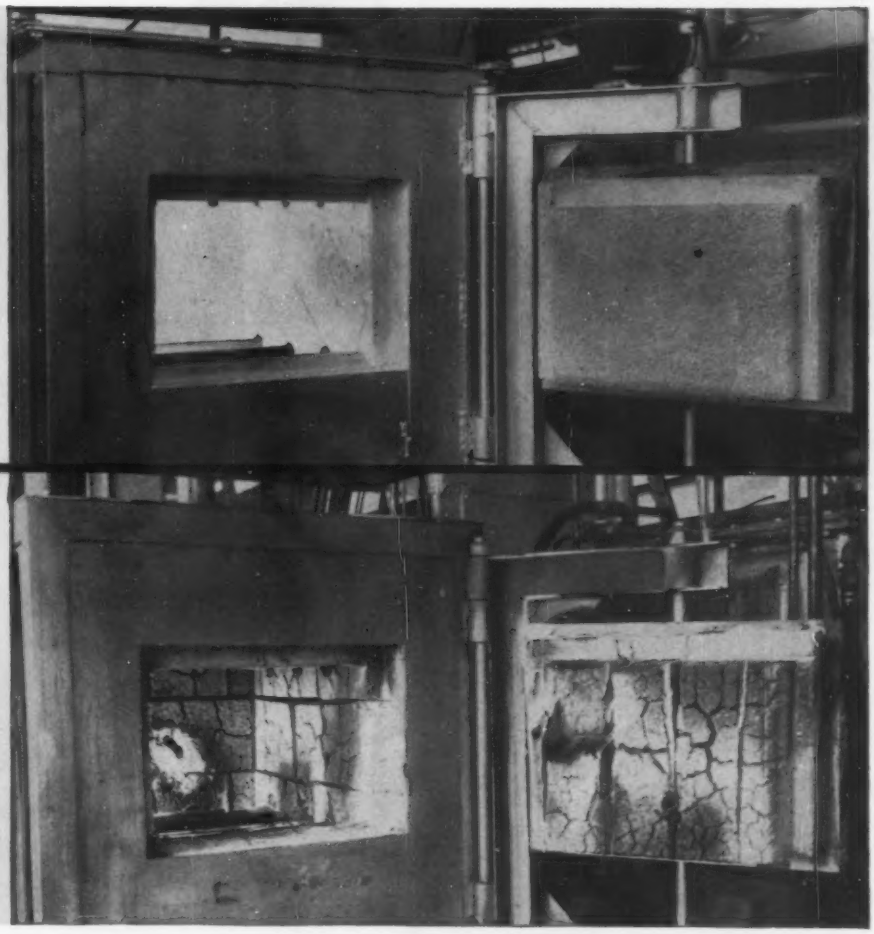

LINED WITH ALUNDUM 33-I CASTABLE, this furnace has been used for almost a year as a periodic furnace for high-temperature laboratory test work. During this time the door was opened and closed over a thousand times with the furnace at temperature. Even after this rugged service, the ALUNDUM Castable lining shows hardly any signs of wear.

LINED WITH A COMPETITIVE HIGH GRADE INSULATING BRICK, this similar furnace was used in the same service for an equal length of time. Under equally severe thermal shock conditions the lining cracked and spalled and this furnace must be rebuilt.

You get higher temperature protection with ALUNDUM* castables

Up to 3300° F!

ALUNDUM 33-I Insulating Castable is made up primarily of countless tiny, pure aluminum oxide bubbles. Forming a network of air spaces it provides excellent insulation, even at the highest commercial temperatures.

ALUNDUM 33-HD Heavy Duty Castable is chiefly composed of dense grains of pure aluminum oxide. It is recommended for forming dense monolithic surfaces in constructing many types of furnaces where high temperature conditions are more severe.

Both ALUNDUM 33-I and 33-HD Castables protect at temperatures up to 3300° F and are very easy to mix and use. You can cast simple or complex shapes with them quickly and inexpensively for many installations and replace more expensive pre-fired shapes.

See your Norton Representative for more facts on how these new Castables can provide long, trouble-free service that saves you time and money. Ask him for the folder *Two New Norton Castables*, or write for your free copy to NORTON COMPANY, Refractories Division, 467 New Bond St., Worcester 6, Mass.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

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Consolidated process converts sludge acid to fresh, 99% sulphuric

Consolidated Chemical's regeneration process converts the heaviest sludge acid of lowest concentration into pure, white, 99% sulphuric and returns it to service . . . at a saving. Turning problems into assets is typical of Consolidated, which has been a pioneer in sulphuric acid manufacture and recovery for almost 40 years.

Whether your requirement is for new acid or regeneration of spent acid, you will find the facilities and services you need at Stauffer Chemical's plants in Ft. Worth, Houston, and Baytown, Texas; Baton Rouge, La., Le Moyne, Ala.; and in the Los Angeles and Chicago areas.

Turn *your* disposal problem into an asset. Get information on point of shipment, price and delivery. You'll like doing business with Consolidated.

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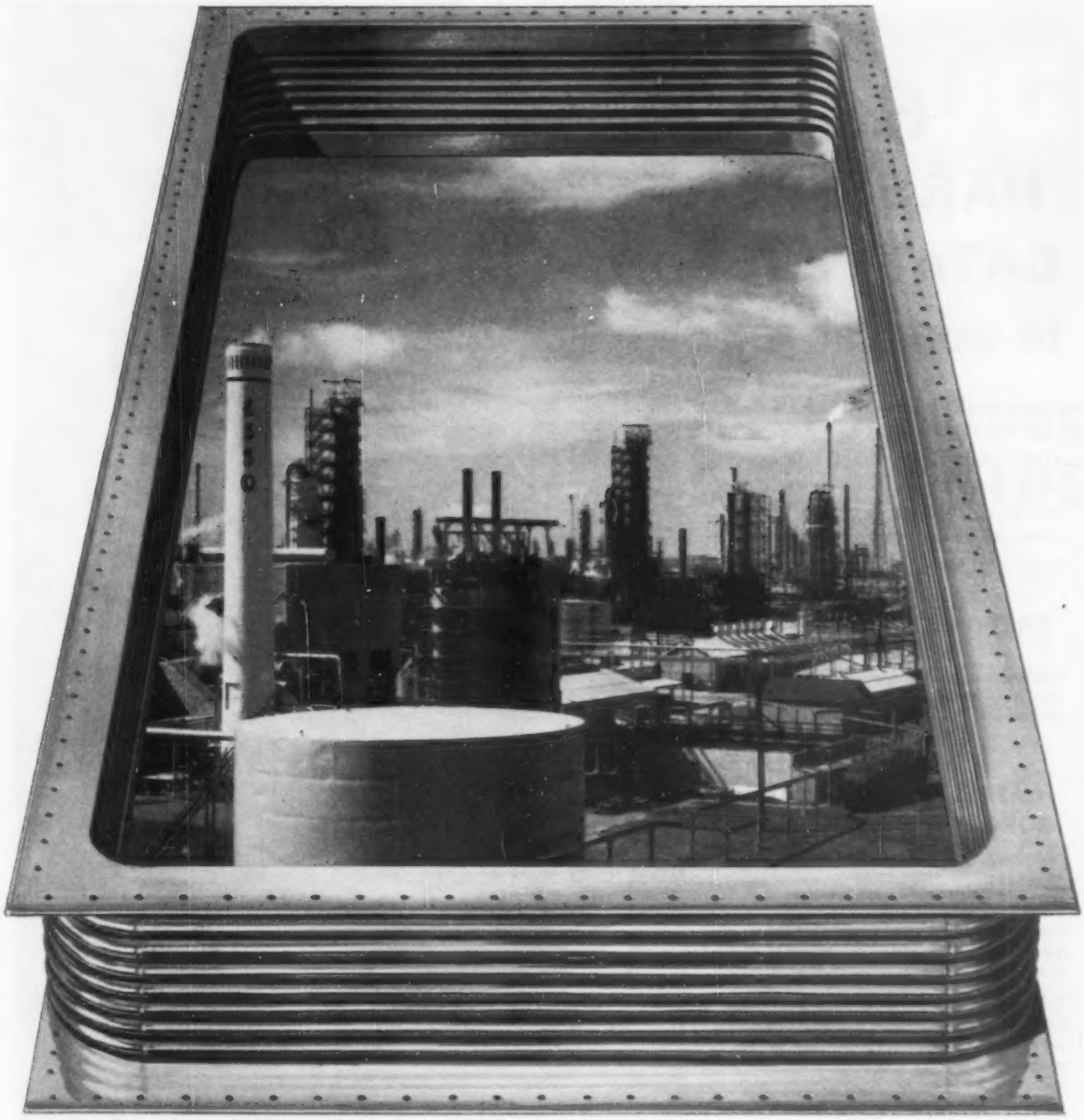

Giant refineries like Esso Baton Rouge use Sola-Flex® Expansion Joints

FORTY OF AMERICA'S FIFTY largest businesses—power, petro-chemical, nuclear and others—use Sola-Flex expansion joints to help solve difficult piping problems. The giant Esso refinery at Baton Rouge has installed 6 ft rectangular Sola-Flex joints in some of its critical equipment where it is necessary to handle difficult extremes of thermal growth and vibration.

Solar manufactures the most comprehensive line of expansion joints in the world. They are made in a wide variety of stainless and high-temperature alloys in a complete range of sizes, from ½ in. to 35 ft in diameter. Temperatures range from –320F to 1200F, pressures from complete vacuum to 600 psi and up. *And rugged, economical Sola-Flex joints can be "in service" one to four weeks after receipt of order!*

A new pamphlet describes Solar's complete line of Sola-Flex expansion joints. Write for it to Dept. F-50, Solar Aircraft Company, San Diego 12, Calif.

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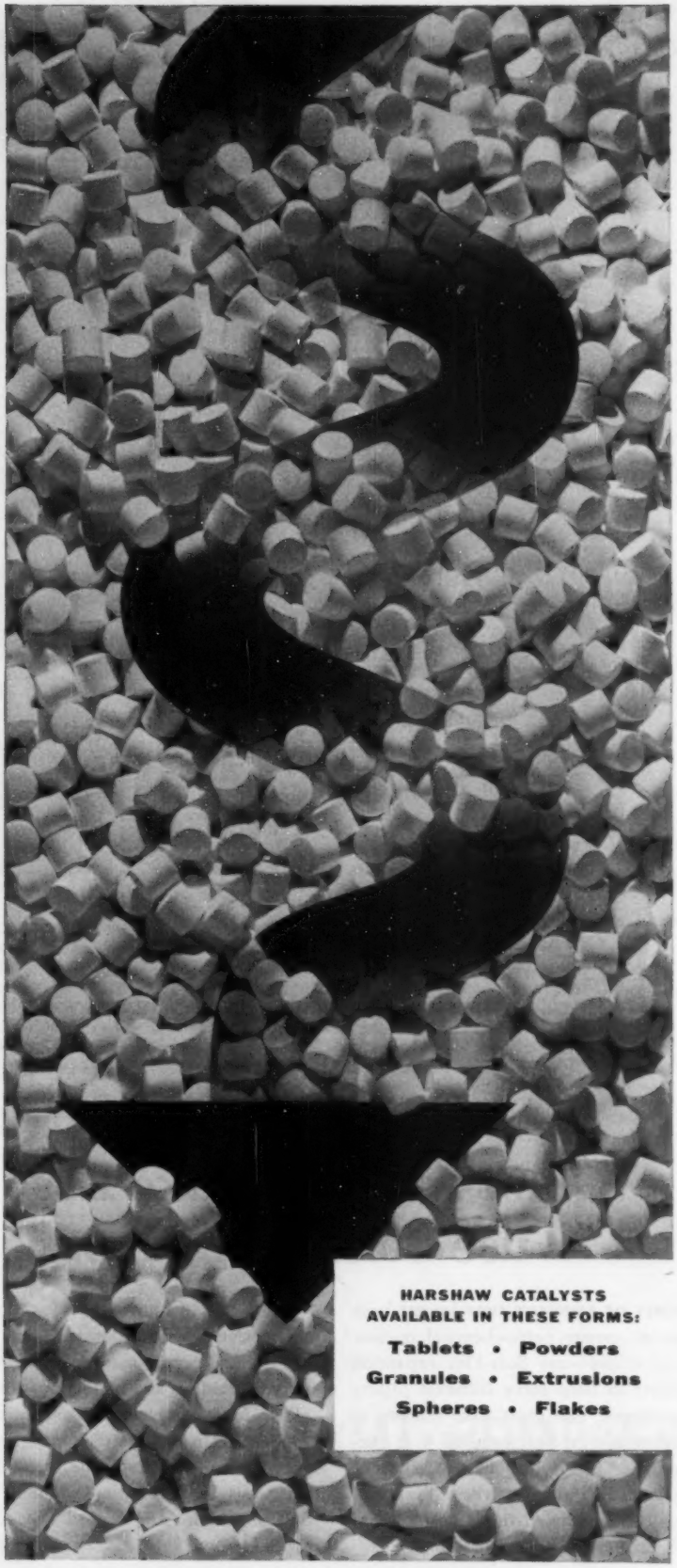

HARSHAW CATALYSTS AVAILABLE IN THESE FORMS:

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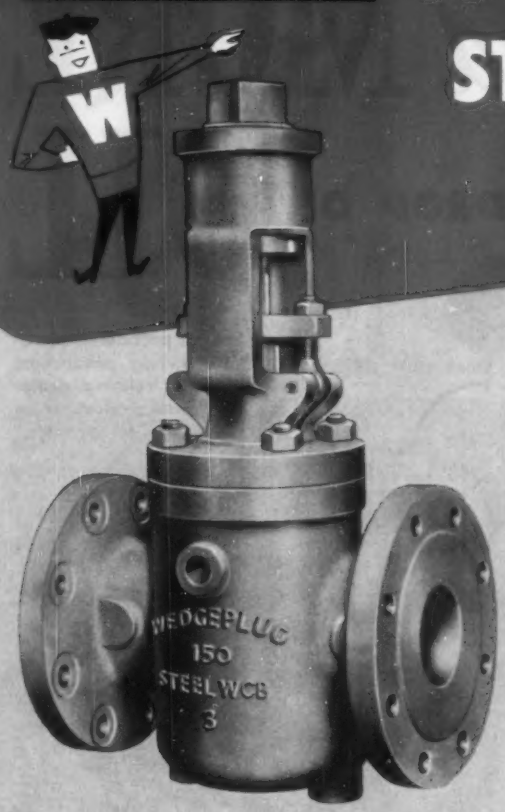
WEDGEPLUG STEAM-JACKETED VALVES



...for handling VISCOUS LIQUIDS

Typical Services Where Steam-Jacketed Wedgeplugs Have Outstanding Performance Records

ASPHALT	+500° F. — 100 PSI
RESINS	+400° F. — 80 PSI
MOLTEN SULPHUR	+275° F. — 80 PSI
SOFT PITCH	+900° F. — 440 PSI

- **POSITIVE CONTROL** at high temperatures. The Plug lifts, turns and re-seats in one, quick, easy operation. Valve seats are protected; no field adjustment is necessary for varying temperatures.
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Specify Wedgeplugs and get the *Best Valve* for use on lines handling:

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FATS • SOAP
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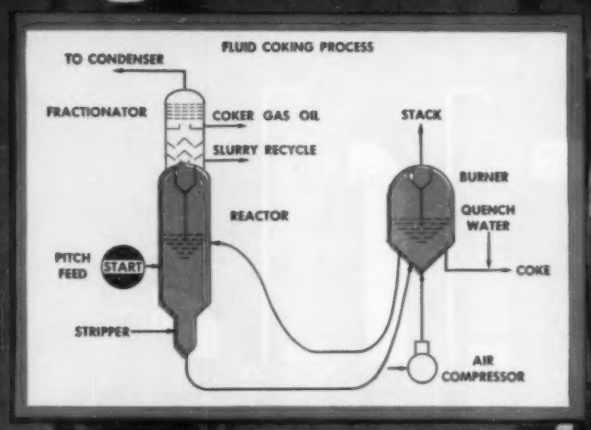

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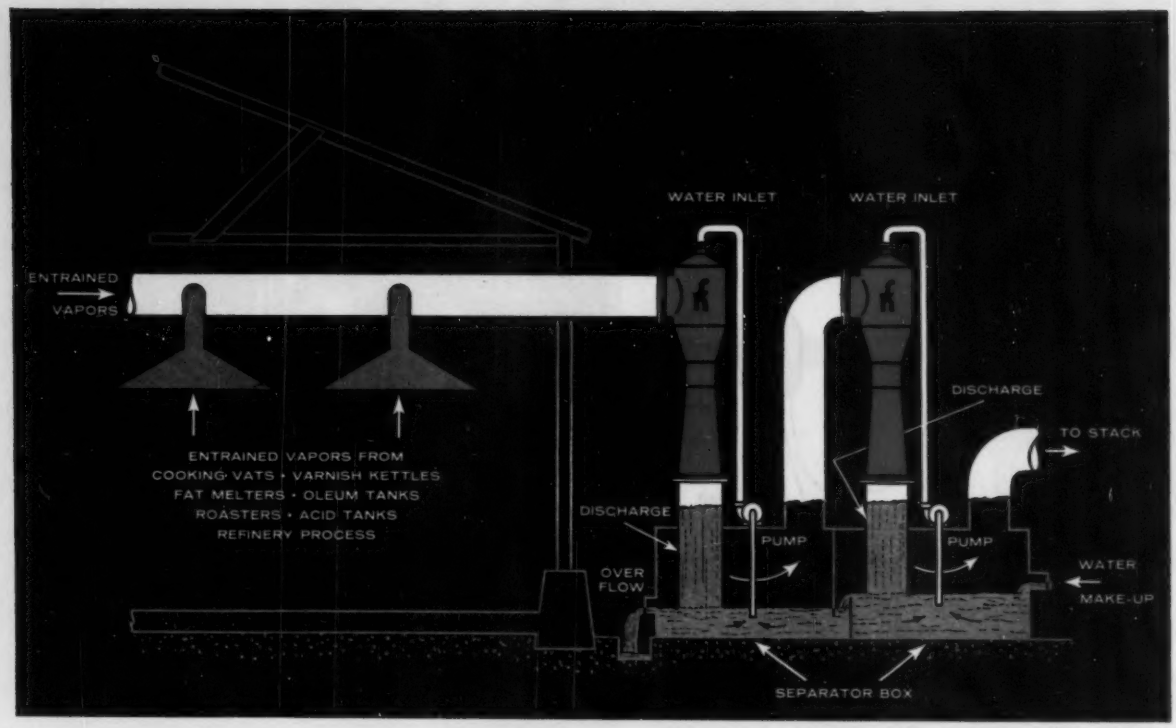
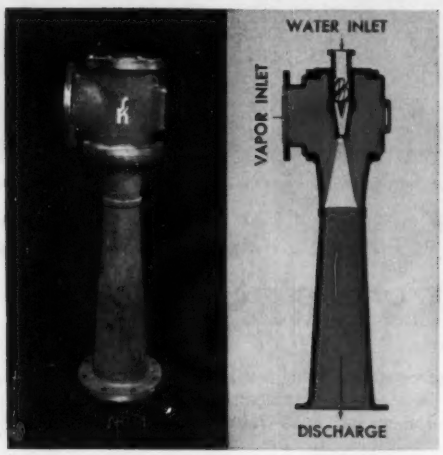


CONTROL OBJECTIONABLE FUMES, GASES, VAPORS

with an economical SK Fume Scrubber

Photo and sectional drawing of
an SK Fig. 4010 Fume Scrubber



A food plant in California uses an SK Fume Scrubber to condense steam and scrub oil vapors from cooking vats. A large chemical manufacturing plant on the eastern seaboard uses a battery of SK Fume Scrubbers to condense steam and purge entrained gas containing H_2SO_4, SO_2, H_2S, TiO_2, and ore dust. A mid-western manufacturer uses SK Fume Scrubbers to vent oleum tanks. A soap maker in Pennsylvania uses a scrubber to remove ammonia fumes from a plant building and cool the building at the same time.

From coast to coast, chemical and food processing plants, refineries, paint and varnish manufacturers, fertilizer, and other manufacturing plants are using SK Fume Scrubbers to control objectionable—sometimes dangerous—fumes, gases, vapors, and dusts.

These manufacturers have found that SK Fume Scrubbers are reasonably low in initial cost, require little maintenance, and are an effective means for conforming to local ordinances which prohibit the pollution of air.

Made in a wide range of sizes from cast iron, steel plate, Haveg, stoneware, or other materials or with linings of rubber or Polyvinyl Chloride, or other synthetic materials, SK Fume Scrubbers can help you solve a fume or dust problem. Why not get the whole story. Send for Bulletin 4R which contains complete information on SK Fume Scrubbers.

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by Foxboro...

engineered for the most advanced transmission techniques

Telemetering matched in performance with famous Foxboro instruments — that's the Foxboro Teletax Telemetering System.

Through use of impulse-duration signals, Teletax electrically transmits measurements of a remotely-located variable to the central control station. Here, the Teletax receiver records the duration of impulse, which is directly proportional to the measured variable.

The Foxboro Teletax System is noted for its simplicity, its versatility, and its high sustained accuracy. For a transmission medium, it can use either AC or DC, an audio frequency carried on a transmission line, or radio or microwave impulses. Sustained accuracy is 0.5% of full scale.

TELETAX RECEIVERS

Teletax receivers include: Single or Dual Receivers; Multi-Record Receivers for recording up to 6 separate measurements on one chart; and Teletax Receiver-Controllers for automatic operation. And the Teletax signal can be simply converted to digital information.

TRANSMISSION LINK

With Foxboro's Teletax Telemetering System, you can use the most advanced transmitting techniques: two wire lines, power lines, radio or microwave. As many as 25 different signals can be handled in each direction, simultaneously.

TELETAX TRANSMITTER

The Teletax Transmitter houses either one or two standard Foxboro measuring elements — plus the Teletax transmitting mechanism. It will transmit to a control center hundreds of miles away just as easily as to one nearby. It also indicates or records locally if desired.

The Teletax Transmitter needs no periodic maintenance whatever, while the receiver requires only occasional oiling. And the receiver has a minimum of mechanical components to wear — no clutch to slip or jam.

Foxboro Teletax Systems are now in wide use on natural gas systems, water works, oil fields, power plants, steel mills, etc. Write for Bulletin 17-11C — it gives all the details. **The Foxboro Company, 748 Neponset Avenue, Foxboro, Mass.**

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TELETAX TELEMETERING

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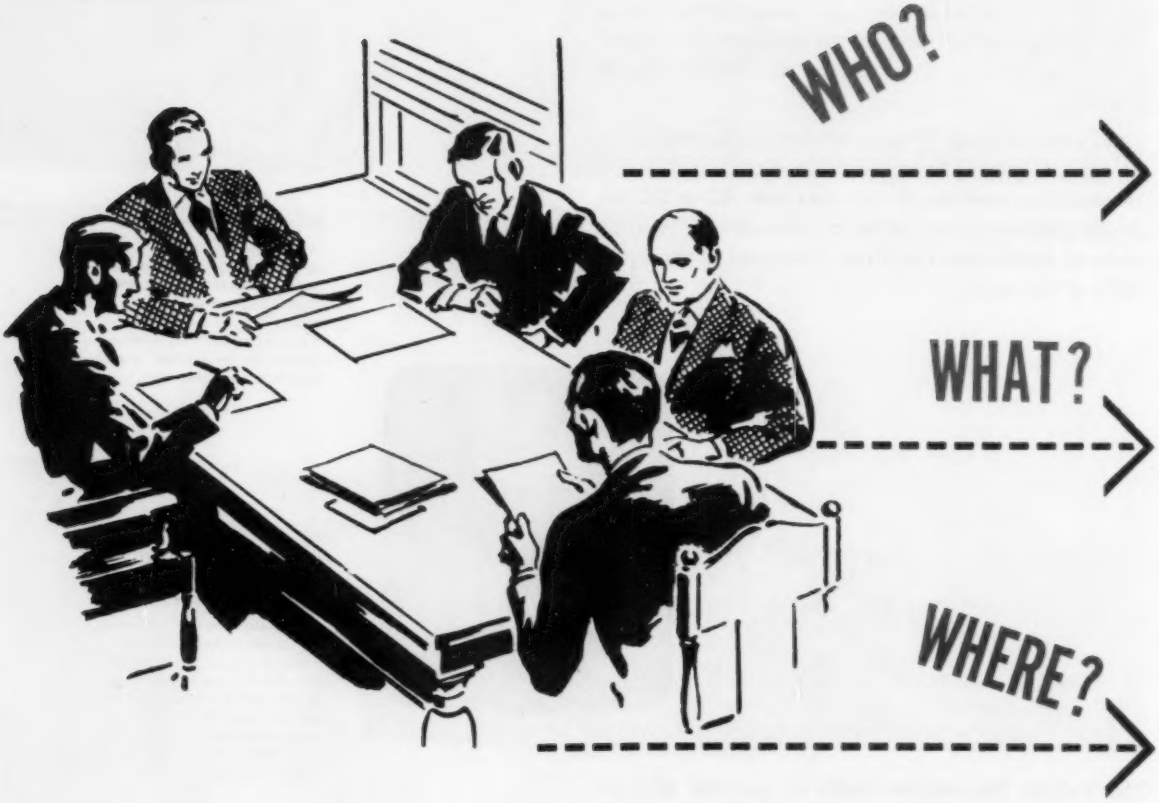

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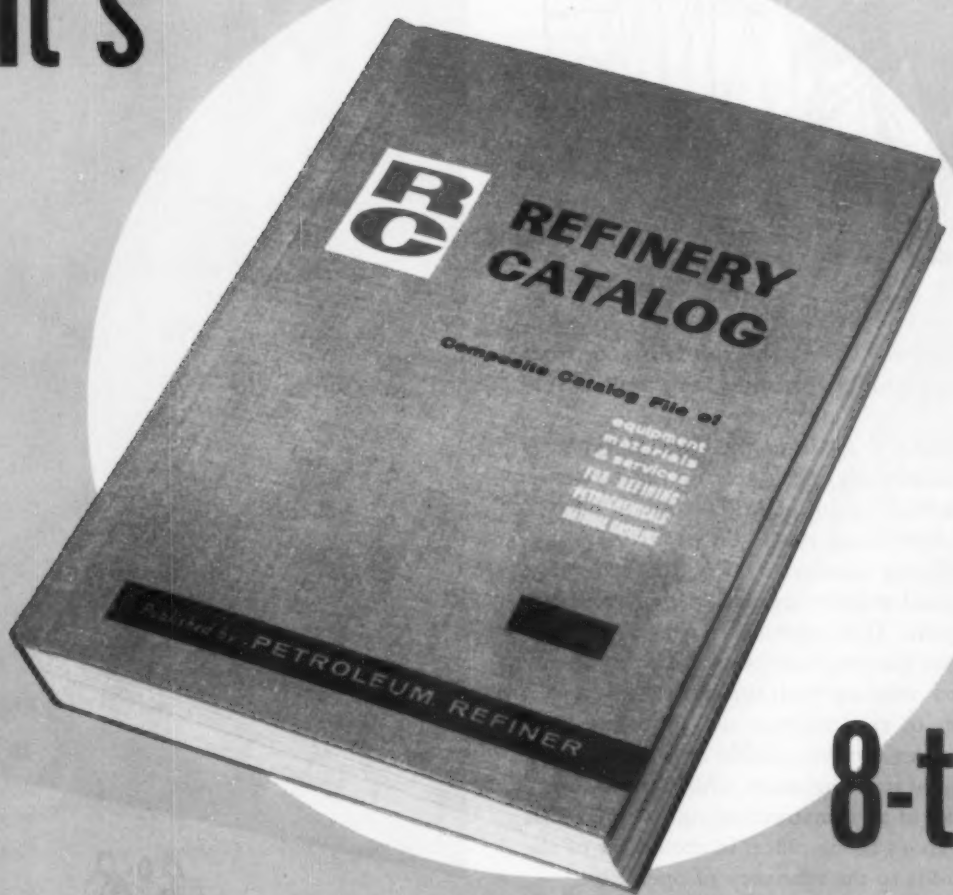

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Look to REFINERY CATALOG for quick answers to your procurement problems in the refining, natural gasoline and petrochemical industry. It's indexed and cross-referenced to save time and eliminate error in planning, buying and specifying for this fast-moving market. That's why buyers and specifiers express a preference of 8-to-1 for REFINERY CATALOG over individual product catalogs.

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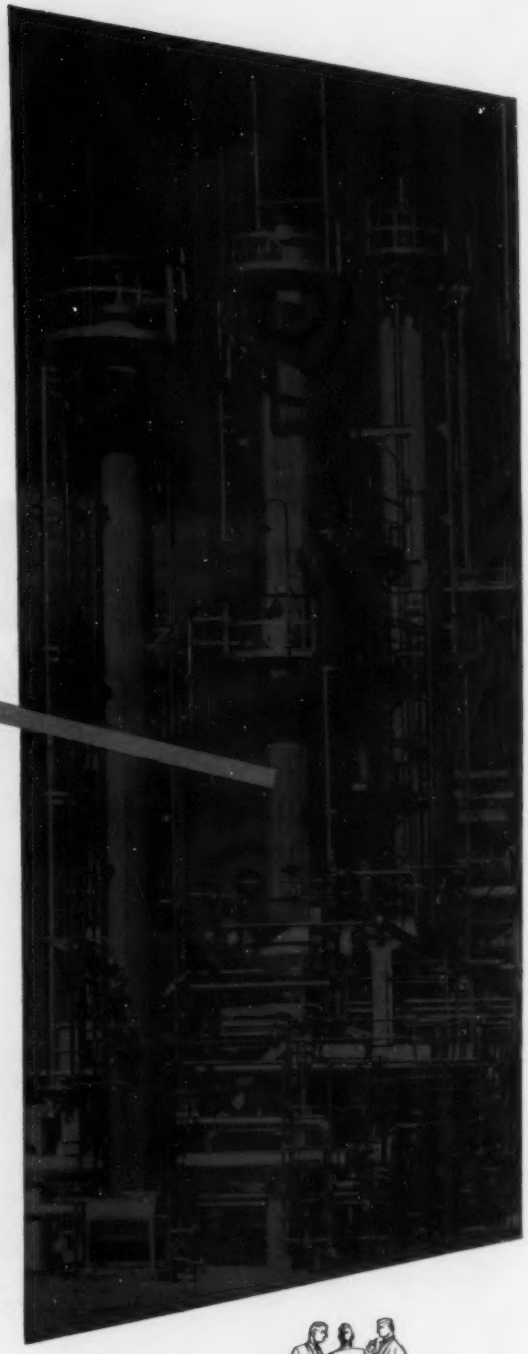

Let Treco show you how short the distance from the ground breaking ceremony to "on stream" can be.

The REFINERY ENGINEERING Company's reputation for fast design, engineering and construction has been built upon the knowledge of how to speed up all operations through careful planning, without sacrificing quality. This is due, in a large degree, to actual refinery-operation experience of Treco's top men. This experience enables Treco to quickly analyze the problem from actual day-to-day contact and to come up with the right answer.

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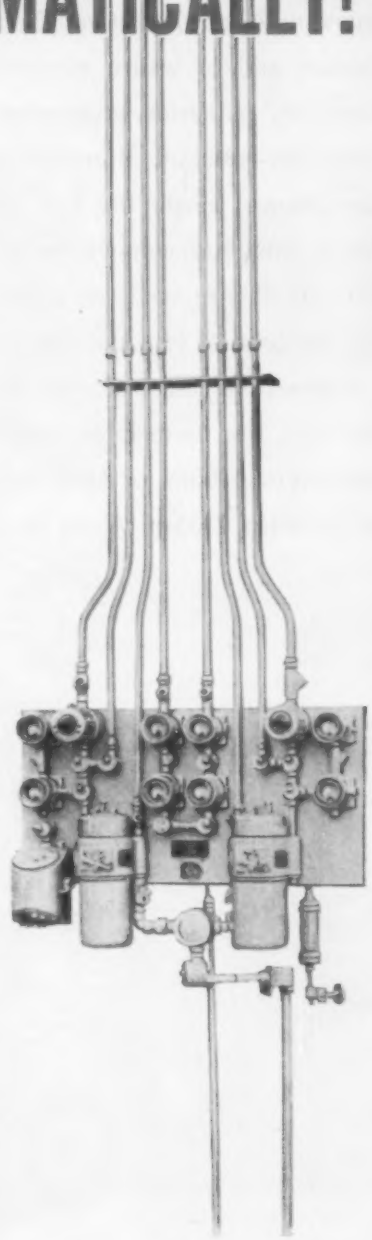

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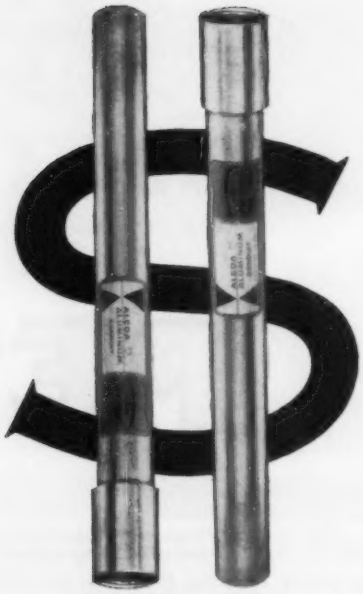

WILL IT WORK? Of course—it's a Rockwell-Nordstrom *lubricated* plug valve. Even after months in an open or closed position, the *lubricated* plug responds instantly for easy, quarter-turn operation. While there can be no compromise with absolute dependability, you pay no more, often less, for the superior reliability of Rockwell-Nordstrom valves.

Whatever your flow control needs, specify Rockwell-Nordstrom . . . the world's most *complete* line of lubricated plug valves. Rockwell Manufacturing Co., Pittsburgh 8, Pa.

ROCKWELL-Nordstrom VALVES

it's **ROCKWELL**

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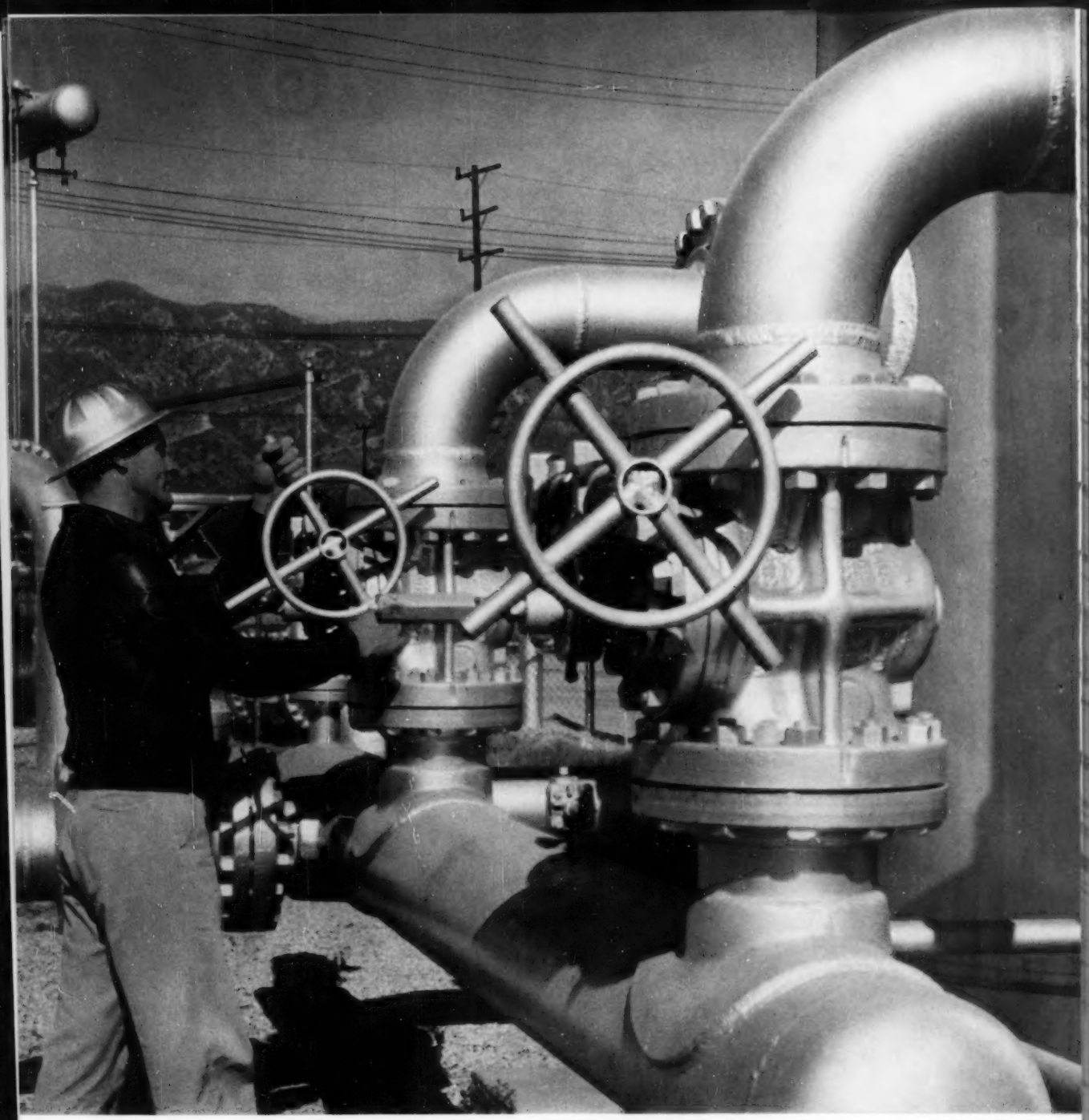

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Some valves aren't really off when they're shut because their exposed seats soon wear or cut. Rockwell-Nordstrom valves are sealed by a tough, instantly replaceable film of pressurized lubricant and the seats are never exposed to the line . . . they *stay* leakproof year after year.

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ROCKWELL-Nordstrom VALVES

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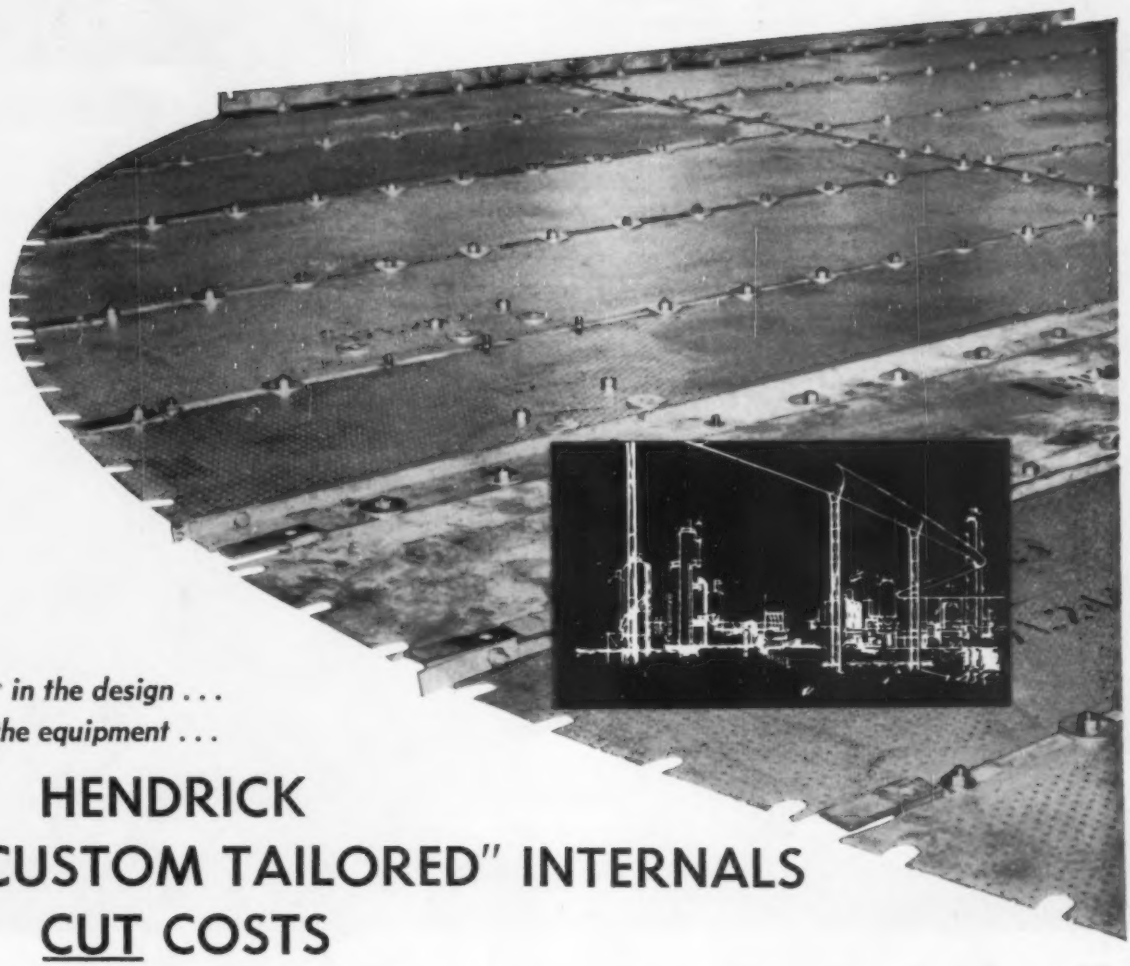

in the design . . .
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HENDRICK "CUSTOM TAILORED" INTERNALS CUT COSTS

Here's how you save when you use Hendrick perforated metal plate

HENDRICK PLATE HAS CLEAN CUT PERFORATIONS. Decks are completely fabricated from Hendrick's own perforated metal to your selected hole size and spacing and—straight or indented. This assures clean cut perforations, uniformity of mesh and long service life.

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For more detailed information, mail the coupon below. A Hendrick representative will be happy to meet you.

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stocked by Carlson

- keep your working capital working
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- give you prompt delivery

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The Carlson stock is made up of ASME and Standard flanged and dished stainless steel heads. They range from 10″ O.D. through 72″ O.D., in 6″ increments, 3/16″ through 3/8″ Gauge, in Types 304, 304-L, 316, and 316-L. All are fully annealed and pickled after forming to provide maximum corrosion resistance. Flanges can be machined to your specifications in a matter of days.

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Stainless Steels Exclusively

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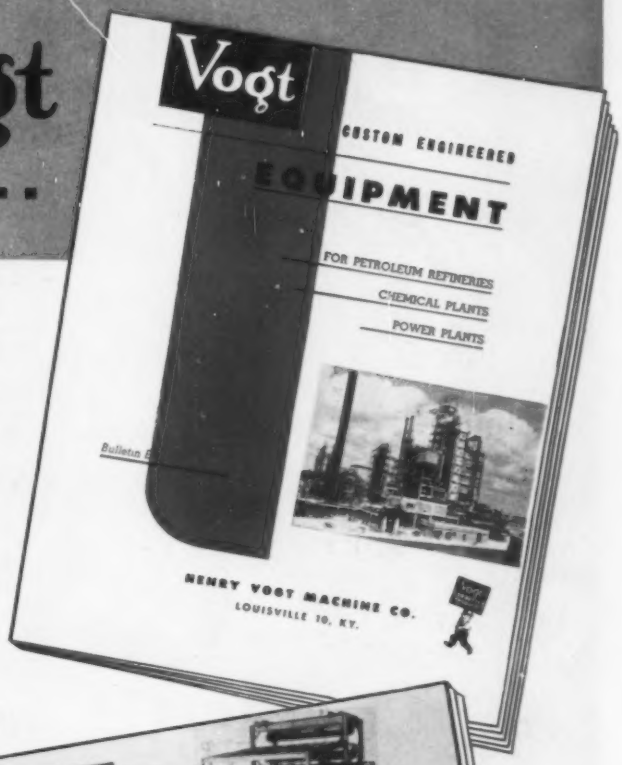

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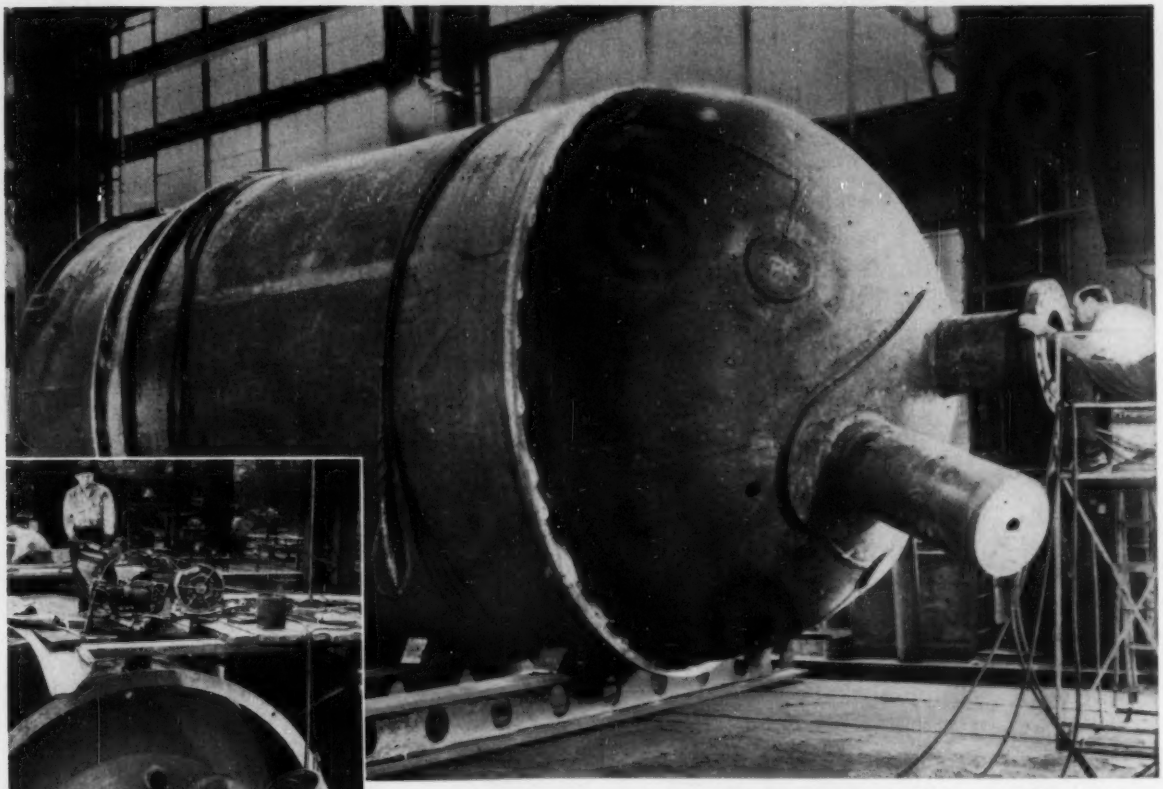
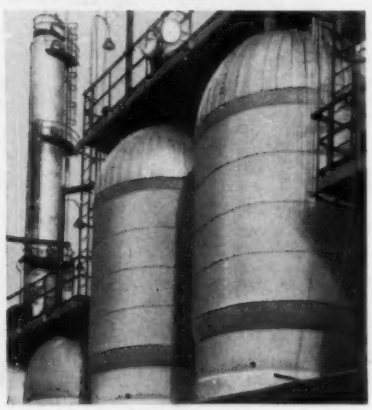
20 ft. long, 12 ft. in diameter, 13 kinds of steel . . . typical of the tough pressure vessel welding jobs Baldwin is noted for



Built by B-L-H's Eddystone Division, a 100-ton pressure vessel made chiefly of chrome molybdenum steel is here shown being inspected by an Eddystone engineer.

Automatic submerged metal arc was one of three welding methods employed on this huge pressure vessel.



Identical vessels fabricated by B-L-H and installed in the catalytic reforming unit of an ultramodern refinery.

A major oil company recently called on Baldwin-Lima-Hamilton's Eddystone Division to weld two identical 100-ton pressure vessels that must operate continuously for long periods of time at nearly 1000°F in a hydrogen-rich atmosphere at pressures up to 536 psi. Baldwin successfully met the challenge of this big job.

Thirteen different kinds of steel ⅜ in. to 5⅛ in. thick and three welding methods—manual-shielded metal arc, automatic submerged metal arc, and inert gas — had to be used on the vessels, each 20 ft. long, 12 ft. in diameter. As on all Baldwin work, only qualified welders were used.

Radiographic inspection of all welds revealed no defects. After the vessels were hydrostatically tested at 1575 psi for 3 hours, all seams were examined for leaks and found to be tight.

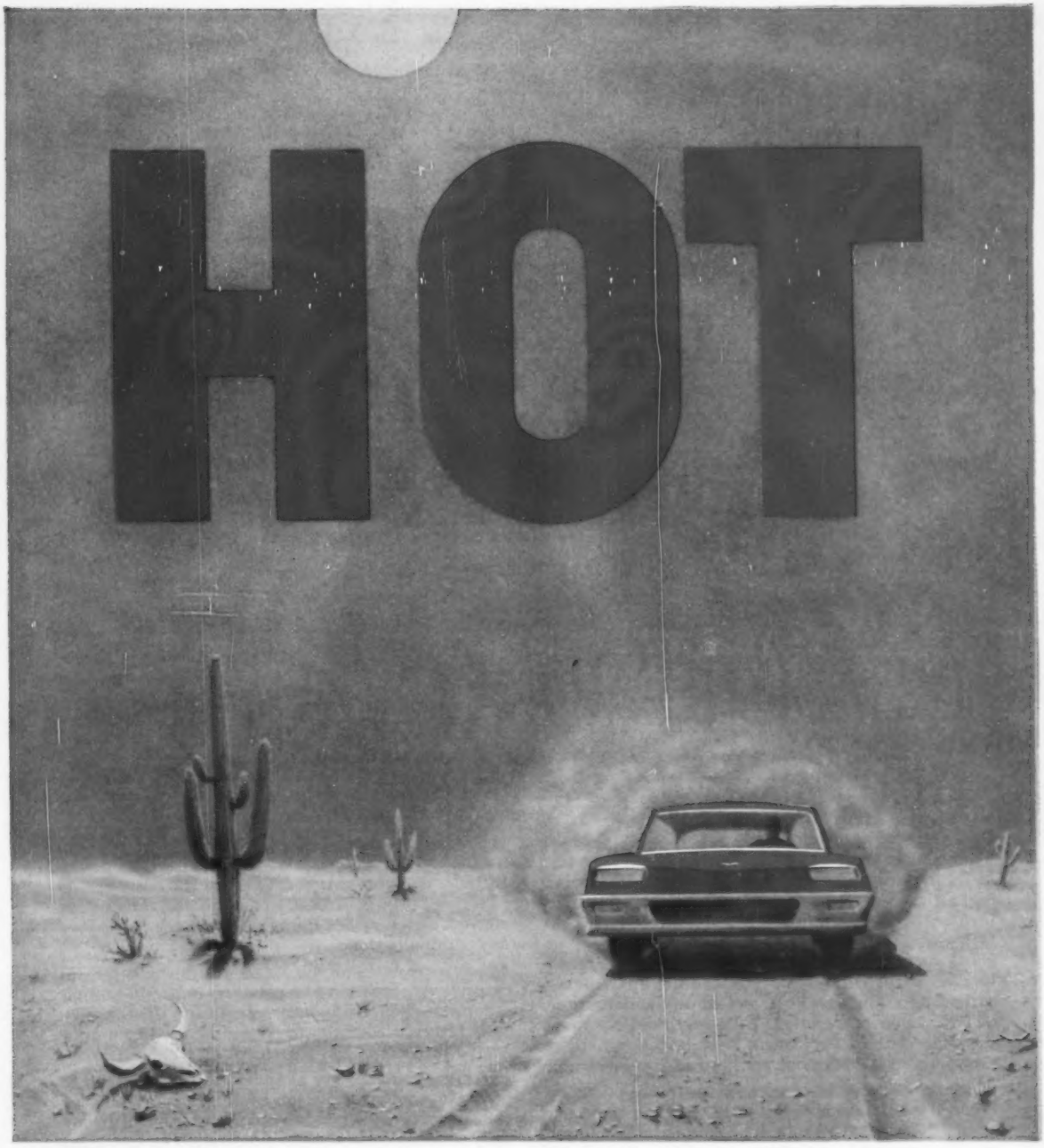
For a copy of our illustrated Weldment Bulletin 7001 or for specific information on how we may be of service to you, write to B-L-H Corporation, Philadelphia 42, Pa.

BALDWIN · LIMA · HAMILTON

Eddystone Division

Philadelphia 42, Pa.

Hydraulic turbines • Weldments • Dump cars • Nonferrous castings • Special machinery • Bending rolls • Machine tools



OR COLD... PARATONE-BLENDED OILS STAND UP!

When the heat's on, inside and out . . . metal-scorching temperature in the engine—sweltering radiation from the hot summer sun . . . ordinary oils become dangerously thin. But oils blended with Enjay Paratone® viscosity index improver stand up to oil-thinning heat and retain their lubricating viscosity. Yet when winter sets in, Paratone-blended oils do not congeal to a heavy, sluggish oil. They provide instant lubrication to all parts for quick, cold weather starting.

Enjay has developed the only complete line of high quality additives (Paramins®). To meet the most exacting oil specifications, insist on Enjay Paramins.

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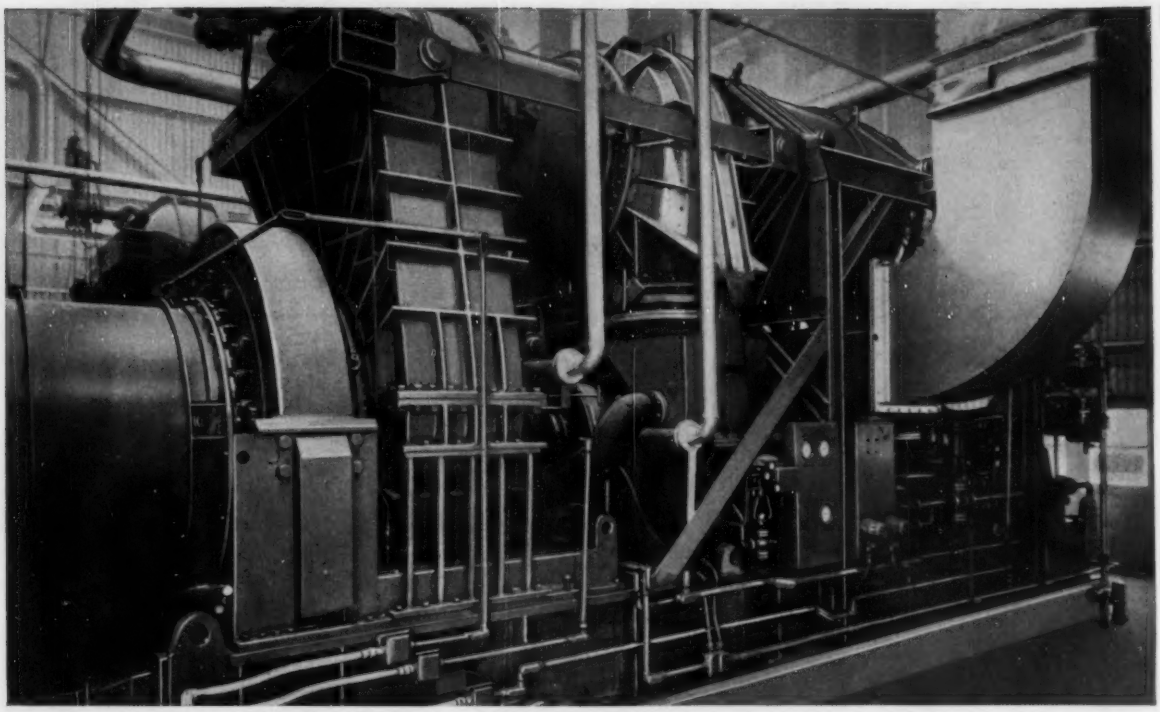


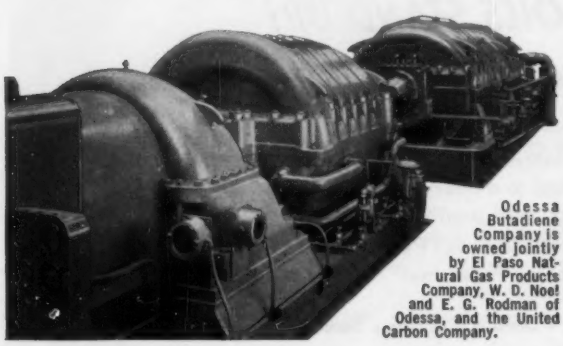
In BUTADIENE APPLICATION Clark Gas Turbines supply regeneration air

Odessa Butadiene Company's new plant at Odessa, Texas, integrates two Clark Model 305 gas turbines in the butadiene process by using them to furnish regeneration air to the dehydrogenation unit. These turbines operate in parallel, along with a Clark 3900 HP centrifugal compressor, and discharge air at 950°F and 22 PSIA into a direct fired heater, then to the reactor catalyst beds where the air removes carbon and replaces heat lost in the endothermic dehydrogenation reaction. This regeneration air is then directed to two waste heat boilers where it generates 186,000 pounds per hour of 250 psi steam.

Clark gas turbines were selected for this application because of better over-all plant economics which resulted from savings in fuel coupled with lower maintenance and operating costs. This plant is an operating testimonial of the dependability and versatility of the Model 305 gas turbine. The power turbine has been removed to allow the hot pressurized gases to be exhausted to the process, rather than convert the energy of the gases to mechanical power as is normally done.

Other services in which Clark gas turbines are in continuous operation are: catalytic reforming, ethylene production, and power generation. In the very near future, additional units will be used in repressuring projects in the Near East and Venezuela.

Clark gas turbines are available in sizes of 1150 to 9300 HP, and are precision engineered and built for the ultimate in dependable and economical heavy duty service. For complete information on Clark gas turbines, contact your nearby Clark representative, or write today for Bulletin 163-1 to Clark Bros. Co., 1315 Lincoln Avenue, Olean, New York.



Odessa Butadiene Company is owned jointly by El Paso Natural Gas Products Company, W. D. Noel and E. G. Rodman of Odessa, and the United Carbon Company.

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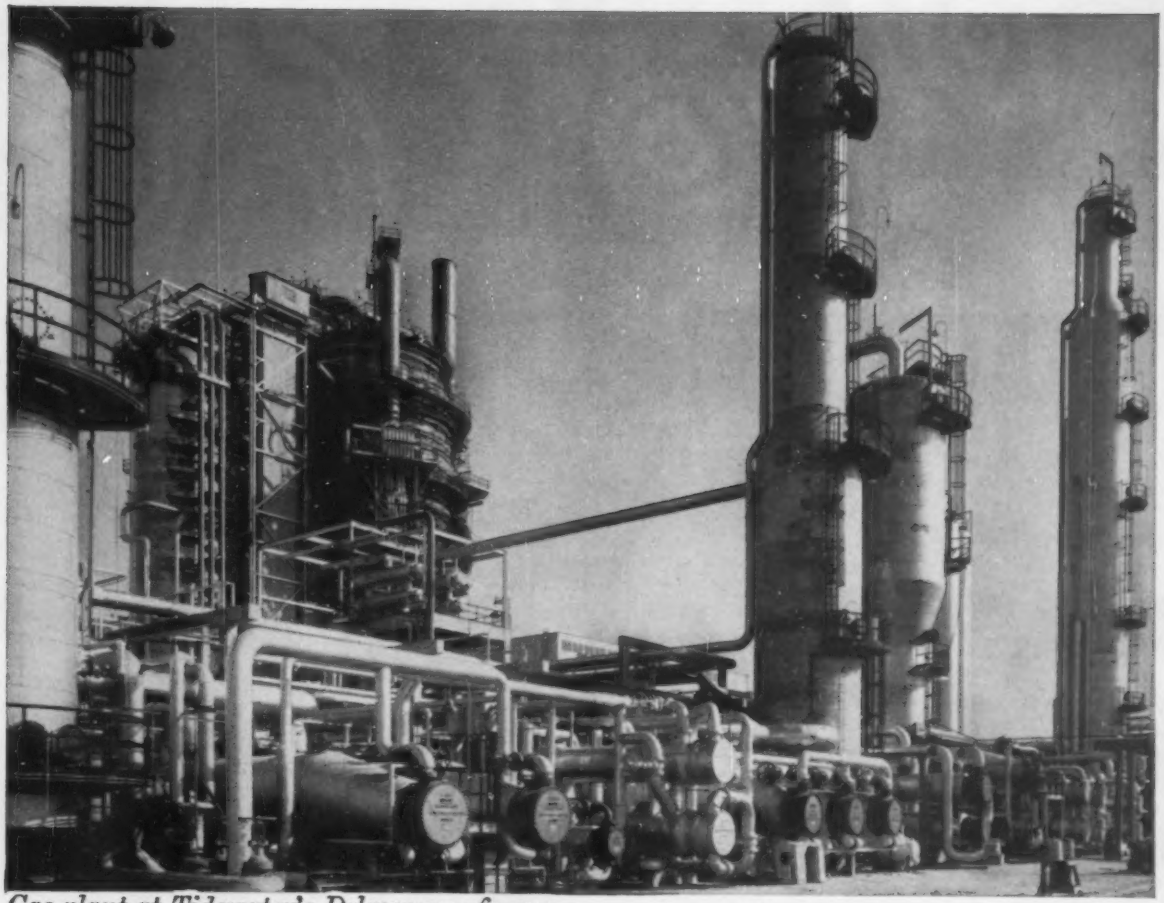

Gas plant at Tidewater's Delaware refinery...

Chromium-nickel stainless steels protect regenerator from H_2S and DEA corrosion

This centralized gas plant serves all of Tidewater Oil Company's new Delaware Refinery, and can treat 88 million cubic feet per day.

Its regenerator separates large amounts of hydrogen sulfide–introduced by the sour crudes handled–from hot diethanolamine (DEA).

Corrosion could have been a problem in this regenerator – especially in its upper section where hydrogen sulfide concentration is high, DEA concentration is low. However, during planning, Tidewater's engineers considered previous operating experience, and with C. F. Braun & Co., job engineers, made detailed investigations of likely trouble points. As a result, Types 347 & 316 chromium-nickel stainless steels were specified for the regenerator.

Nickel-containing stainless steels in other units...

This modern refinery is designed with emphasis on continuous operation of large, single units. Nickel-containing stainless alloys guard against corrosion failure at many points: crude unit columns, parts of the fluid coker, hydrogen plant, cooling water system, many pumps and lines.

For more information, send for "Corrosion Resisting Properties of Chromium-Nickel Stainless Steels." And for assistance with a corrosion engineering problem, write Inco's Development and Research Division. They'll be glad to work with you and help find a solution.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street INCO New York 5, N. Y.

Here's where chromium-nickel stainless steels are used to combat corrosion by H_2S and DEA in regenerator of gas unit at Tidewater's Delaware Refinery.

Equipment	Location	Material
Regenerator shell	Cladding above tray #14	Type 347 Stainless Steel
Regenerator trays	Trays #14 to #18	"
Reflux accumulator	Clad inside surface	"
Reflux accumulator pump	Impeller and casing	"
Piping	Regenerator O.H. to accumulator	Type 316 Stainless Steel
"	Reflux accumulator to regenerator	"

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NICKEL MAKES ALLOYS PERFORM BETTER LONGER

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S VALVES

by CONOFLOW

for the

TOUGH JOBS

SIZES TO 14"
PRESSURE RATINGS TO 2500 LBS.

S valves by Conoflow are on day-in, day-out service handling the tough jobs in many industries. They offer unmatched performance for automatic throttling control of erosive and corrosive slurries, coking oils and liquids, and high pressure pipe line gases, steam and water. **S** valves have proved to be the final answer for such services as alumina refining, pulp mill digester relief, boiler feed water control, and experimental wind tunnels. A few well-known users are: Reynolds Aluminum Co., U. S. Steel, Humble Oil Co., Aluminum Corp. of America, Texas Co., Redstone Arsenal, Knolls Atomic Labs., and Olin-Revere Metals Corp.

The difference is in the design...
The patented, single-seated **S** valve is of heavy, rugged construction throughout. Extra body wall thickness, streamlined contours and heavy stem guiding make the **S** valve especially suited for high pressure drops. Venturi seat ring and parabolic plug assure tight shut-off. Self-sealing bonnet is leakproof. Sizes 1" through 4" carry ASA ratings to 2500 lbs.; sizes 6" and 8" to 1500 lbs. ASA; sizes 10", 12" and 14" - to 300 lbs. ASA.

For complete data on S valves write for Bulletin S-1 to Dept. C-803, Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Penna.

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FOREMOST IN FINAL CONTROL ELEMENTS

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How Do You Plan a Terminal for the Most Efficient Operation?

Do you plan to market gasoline through many high-gallonage outlets? Or do you plan to sell a range of products, such as fuel oil, kerosene and gasoline, through more diversified outlets?

The picture shows two adjacent terminals on the same pipeline designed to operate efficiently under these two different marketing conditions.

The terminal in the background stores gasoline where pumping in and pumping out are almost daily procedures. For such operation, the owner wisely selected three Graver Double-Deck Floating Roof Tanks to combat vapor losses during frequent fillings and emptyings.

In the terminal in the foreground, storage was planned for marketing a variety of products. The Graver Expansion Roof® Tank at the left and the large cone roof tank manifolded to it preserve the volatility of stored gasoline during less frequent turnovers. The two smaller cone roof tanks hold kerosene and fuel oil.

These two adjacent terminals meet two quite different marketing requirements, yet both embody Graver's tested and proved designs for vapor-saving, profit-saving tankage. If you are planning new or enlarged terminal facilities, it pays to plan with Graver.

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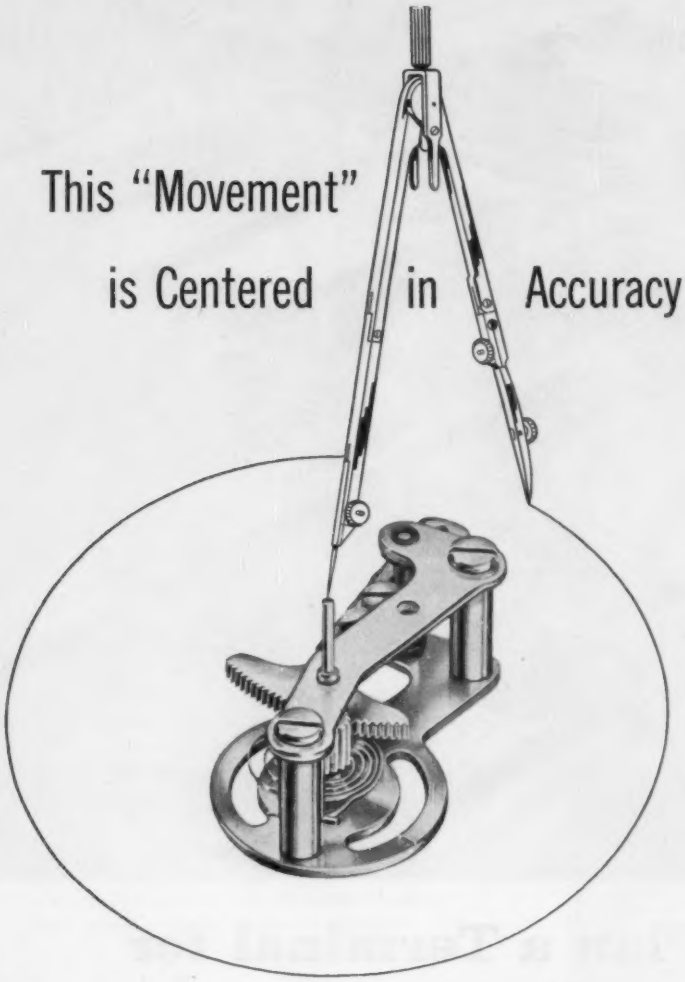
This "Movement" is Centered in Accuracy



The rotary movement in Ashcroft Duragauges has a geared center shaft on which the pointer is mounted. When pressure flexes the Bourdon tube, the pointer is always positively positioned. You can rely on the Duragauge for precise accuracy in measuring pressure no matter how severe the conditions of service.

Correct calibration is guaranteed: the one-piece link between movement and Bourdon tube prevents slippage or parting under tension. Recalibration is easy from front or rear. Universal adjustability permits uniformly graduated dials.

You can order Ashcroft Duragauges with all-stainless-steel movement or stainless steel with nylon bearings and pinion gear. A complete choice of Bourdon tube materials, pressure ranges, dial sizes and case designs and materials is available. Your industrial supply distributor will gladly help you select the best combination for your requirements. So, be certain of highest sustained accuracy, durability and economy – specify Ashcroft Duragauges.

Ashcroft Duragauge in Alumalife® case—a lifetime case made of special aluminum alloy.

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G1-58

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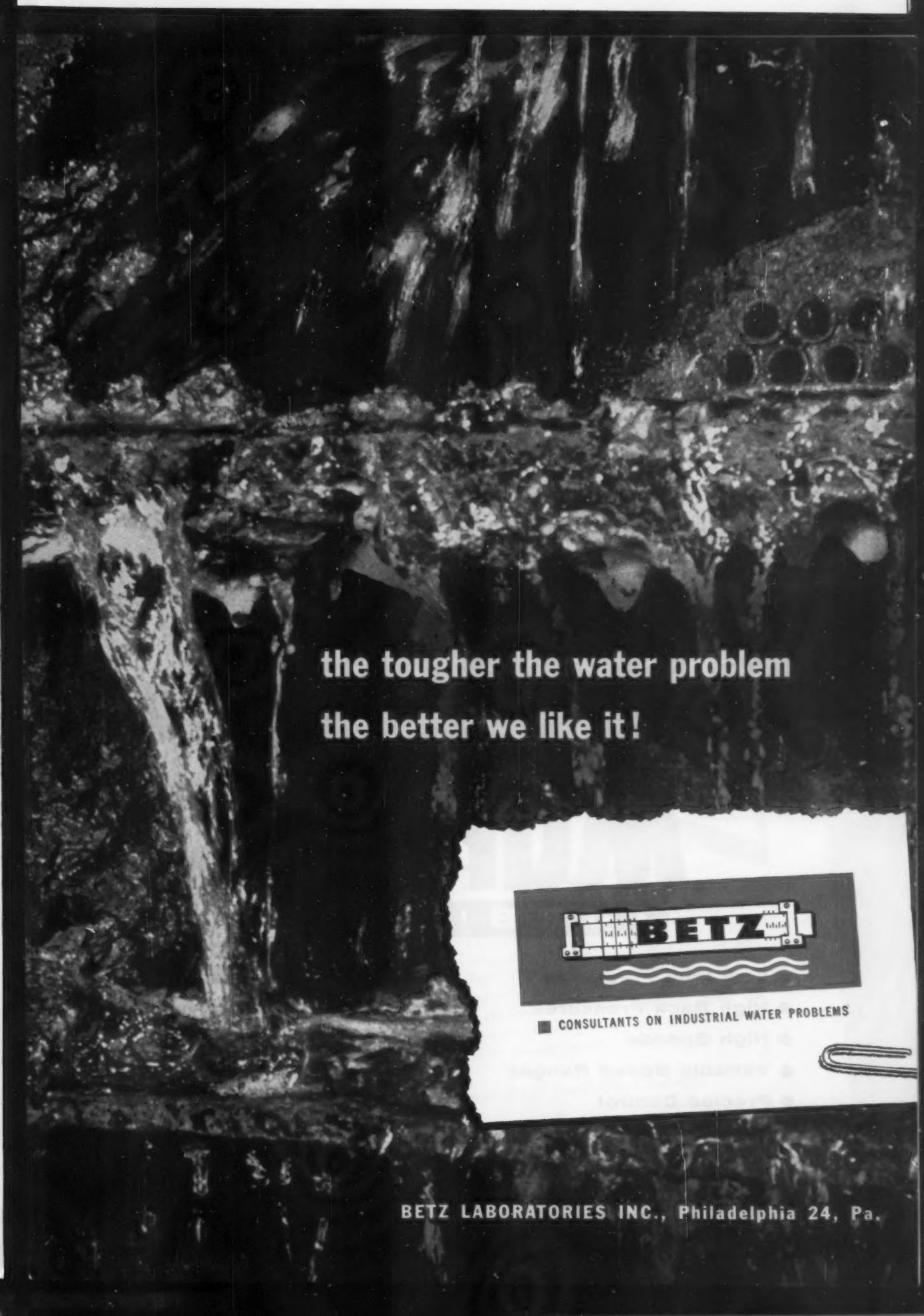
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the better we like it!
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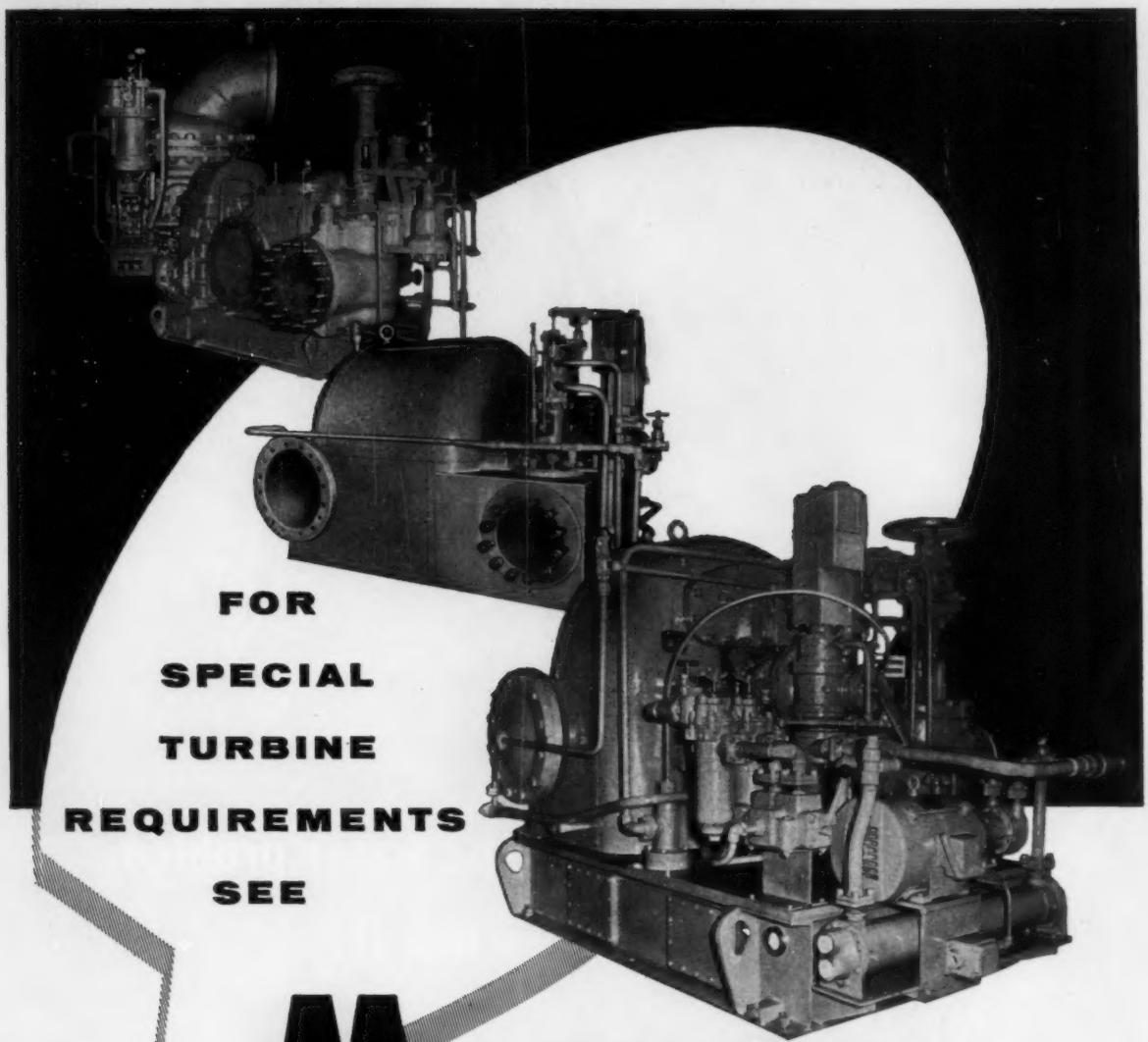
CONSULTANTS ON INDUSTRIAL WATER PROBLEMS
BETZ LABORATORIES INC., Philadelphia 24, Pa.



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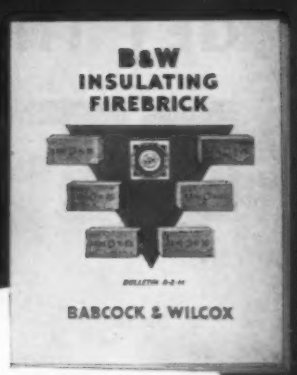
Why B&W IFB for Oil Heater Linings ?

- Lightest weight
- Simplified construction
- High hot load strength
- Lower conductivity
- Lower heat storage
- Better process control



*

The light weight of B&W Insulating Firebrick provides savings in capital investment in several different ways. The light weight of B&W IFB permits thinner wall constructions of equivalent insulating value. These thinner, lighter walls mean real savings in structural steel and concrete. Construction is further simplified because B&W IFB's high hot load strength makes possible higher unsupported walls without deformation at furnace operating temperatures. In addition B&W IFB can be cut and shaped with ordinary wood working tools, simplifying field installation.

The light weight of B&W Insulating Firebrick also provides the greatest insulation. Thus, they save more fuel.

Light weight also means lower heat storage. B&W IFB protect you against burn-out of expensive alloy tubing in the event of forced shutdown. B&W IFB respond faster to changes in firing rate, too, assuring you of more positive process control.

**Write for Bulletin R-2-H giving more data on B&W Insulating Firebrick.*

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R-887

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Make full use of your BTU dollar, with Nicholson traps. They have only one moving part . . . a valve that operates on just a few degrees of temperature differential.

In your steam generation, and in your steam utilization . . . Nicholson traps will save you money. You can try one . . . without obligation! W. H. Nicholson and Company, 12 Oregon St., Wilkes-Barre, Pa. Sales and Engineering Offices in 98 principal cities.

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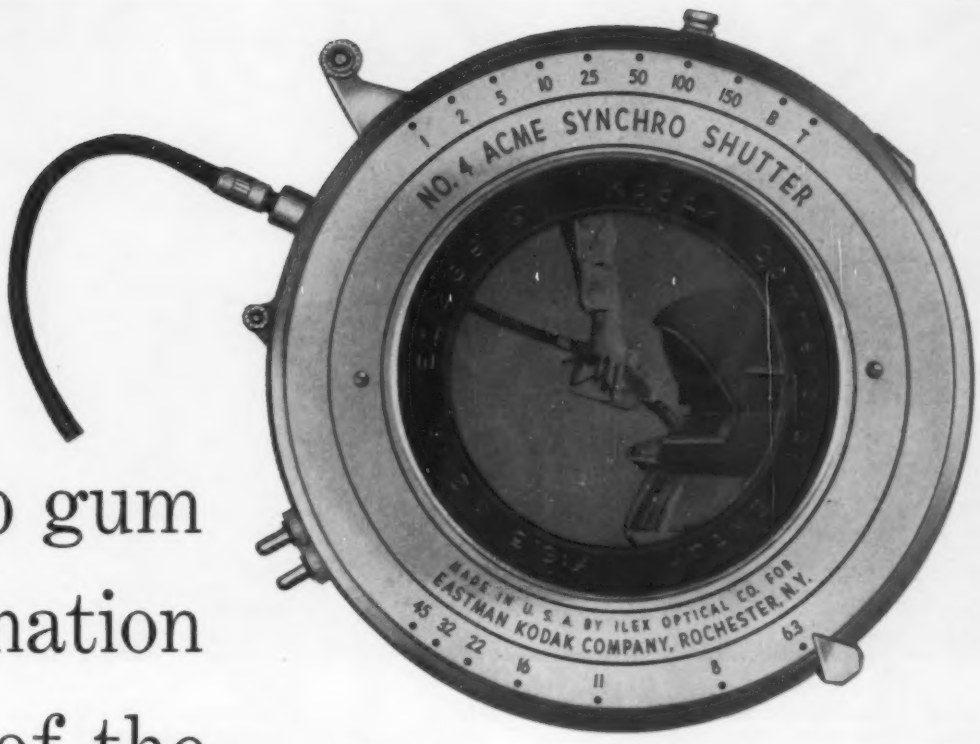
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Your gasolines deliver the performance you build into them when Tenamene additives are present to guard against power-robbing gum formation.

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The quality and uniformity of the Tenamene additives are assured since Eastman manufactures all of the gasoline additives it supplies and exercises precise control over every step in the manufacture of them.

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For more information on Tenamene additives and the service that backs up their proper use, contact our local representative or write to EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

SALES OFFICES: **Eastman Chemical Products, Inc.,** Kingsport, Tennessee; New York City; Framingham, Mass.; Cincinnati; Cleveland; Chicago; St. Louis; Houston. **West Coast: Wilson Meyer Co.,** San Francisco; Los Angeles; Portland; Salt Lake City; Seattle; Denver; Spokane; Phoenix.

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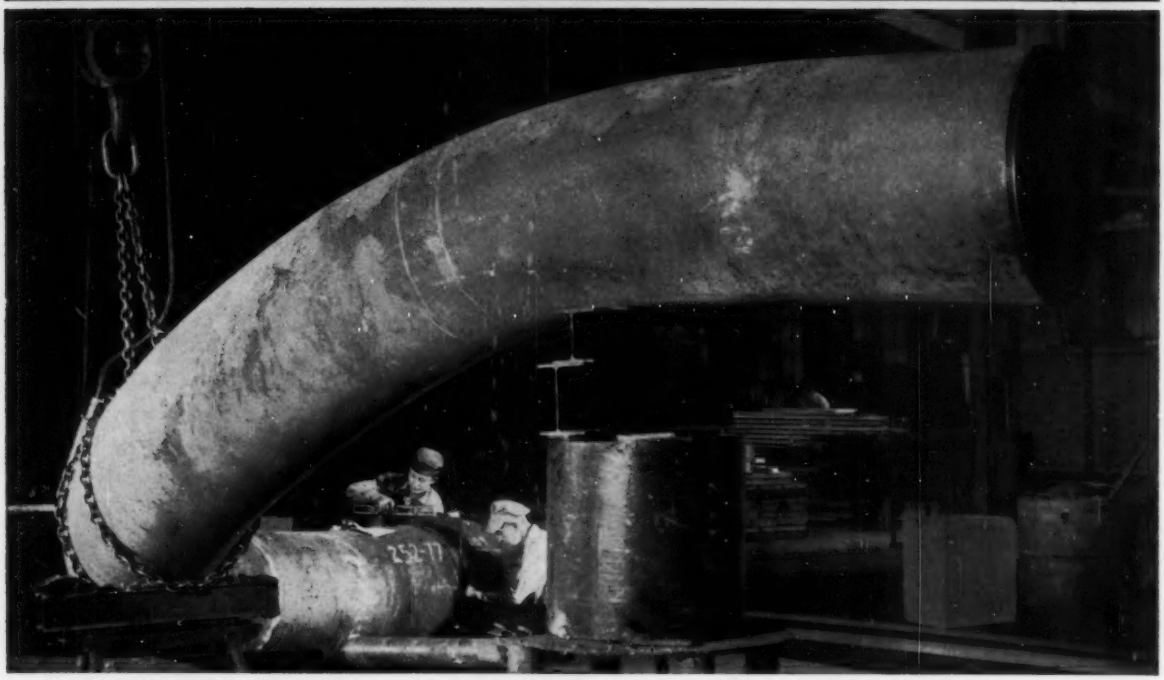

Large chrome moly pipe being readied for shipment to new generating station. Making a right angle bend followed by a 24 degree, 18 foot bend in this heavy 27½ inch chrome moly pipe required all the skill and modern facilities of the Blaw-Knox power piping shop. Before shipment, piping is heat-treated and ultrasonically tested with a radar-type device for detection of any defects.

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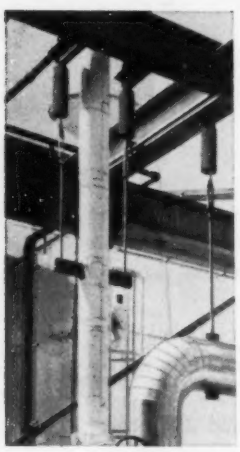

Two-way control over movement of piping is provided by Blaw-Knox functional spring hangers with the patented internal swivel action—shown in this modern outdoor generating station. Our experienced engineers are available to both design and make recommendations for your hanger requirements. To get full information, write for Catalog No. 54.

Each year serious fire strikes one out of every seven manufacturing firms in this country. Be safe. Let a Blaw-Knox fire-protection engineer study your needs—and explain how you can pay for the system on our lease or deferred payment plan. To get more information send for Bulletin No. 2426—"Fire Can Destroy Your Business."

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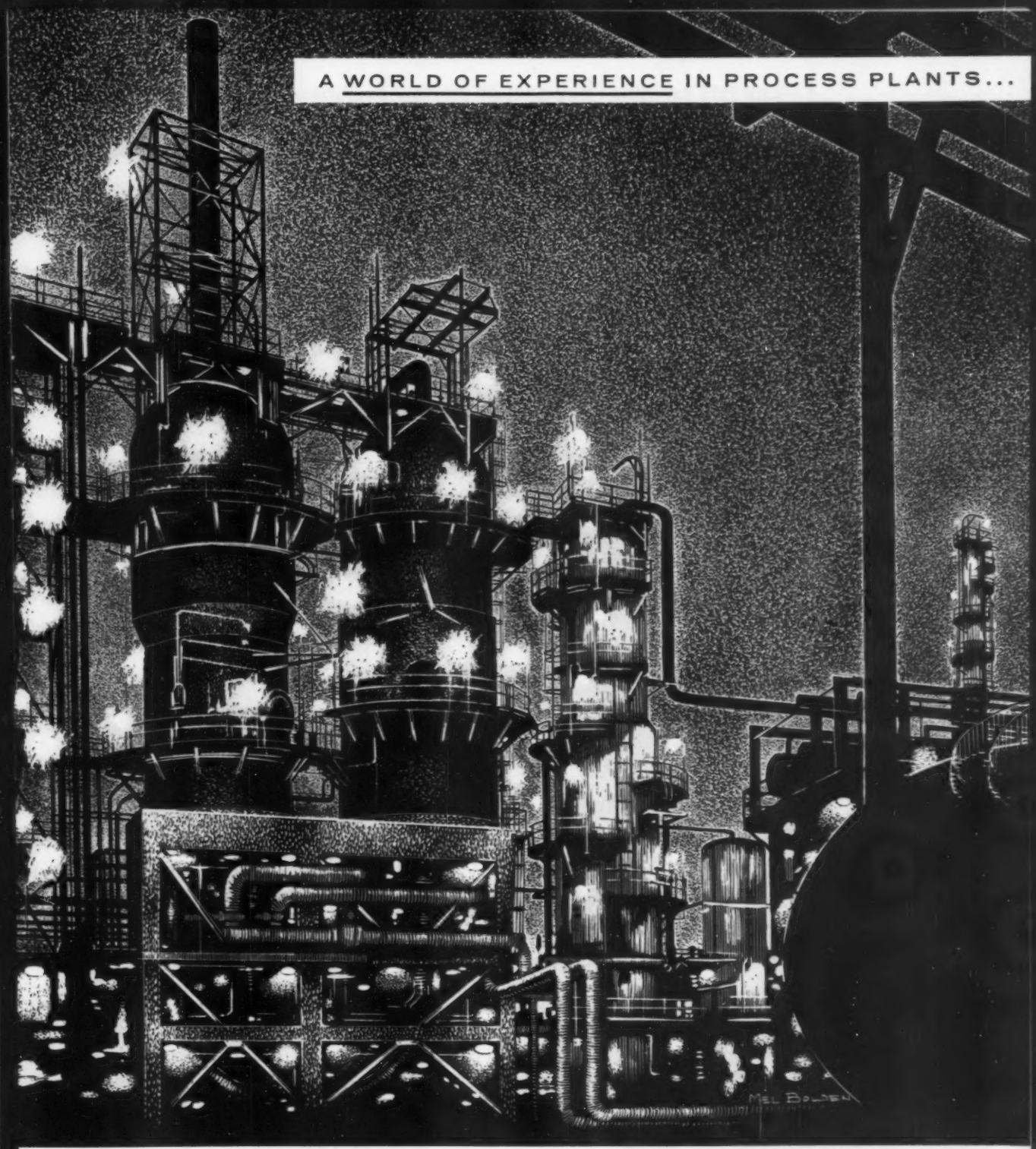
Complete facilities for prefabrication and erection of piping systems for all pressures and temperatures . . . complete line of standard and custom-engineered pipe hangers, supports and vibration eliminators . . . complete line of automatic sprinkler systems for standard and special hazards



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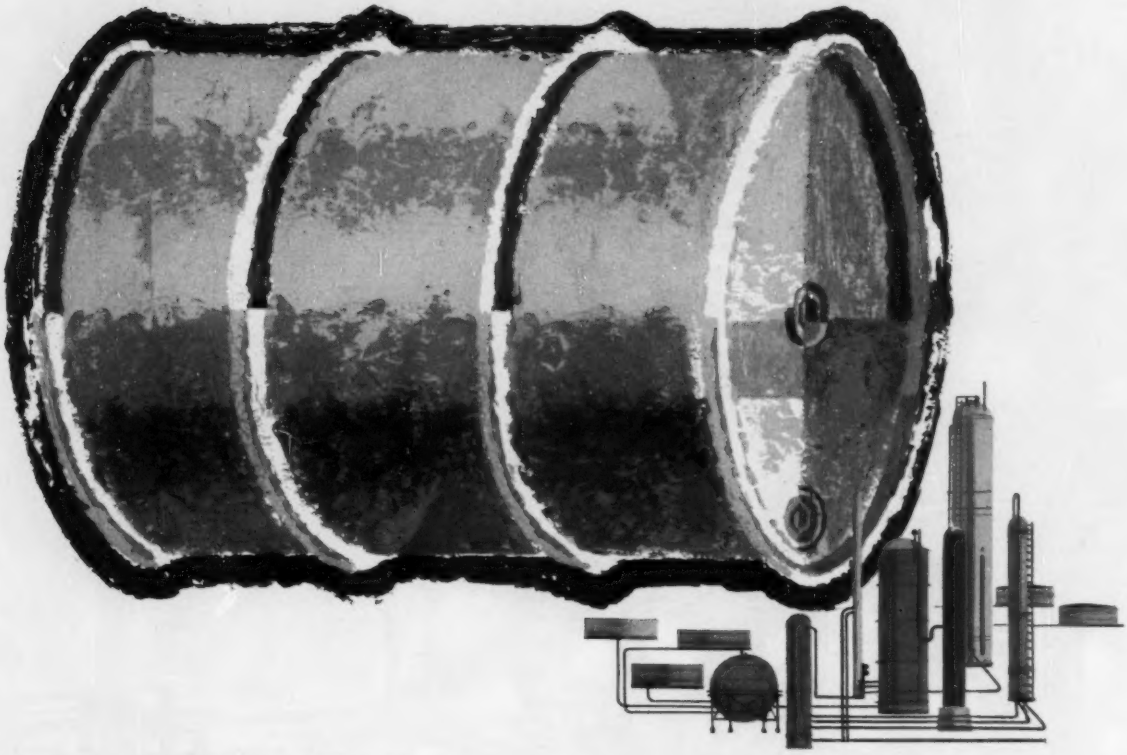
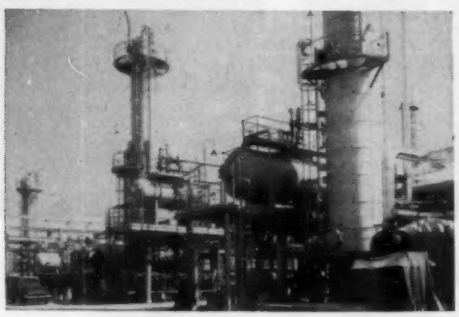


INGENUITY has made KE a leader in refineries and petrochemical plants. For Shell Oil—a multi-million dollar platinum catalyst reformer. For American Gilsonite—coke calcining and off-site facilities. For Texas City Refining—a moving bed catalytic cracker. These are typical of the demanding assignments that Ingenuity brings to Kaiser Engineers. KE can take your refinery project from initial concept through completion. Economic analysis, site selection, process and mechanical design, procurement, expediting, construction, start up—KE does one or all. Throughout, KE ingenuity works to shorten construction time, reduce costs and produce a more efficient, dependable facility. Your next plant or addition can benefit this way—from ingenuity in action. Call KE.



Ingenuity in Action. New multi-million dollar platformer for Shell Oil Company, Wilmington, California. Design and construction by Kaiser Engineers.

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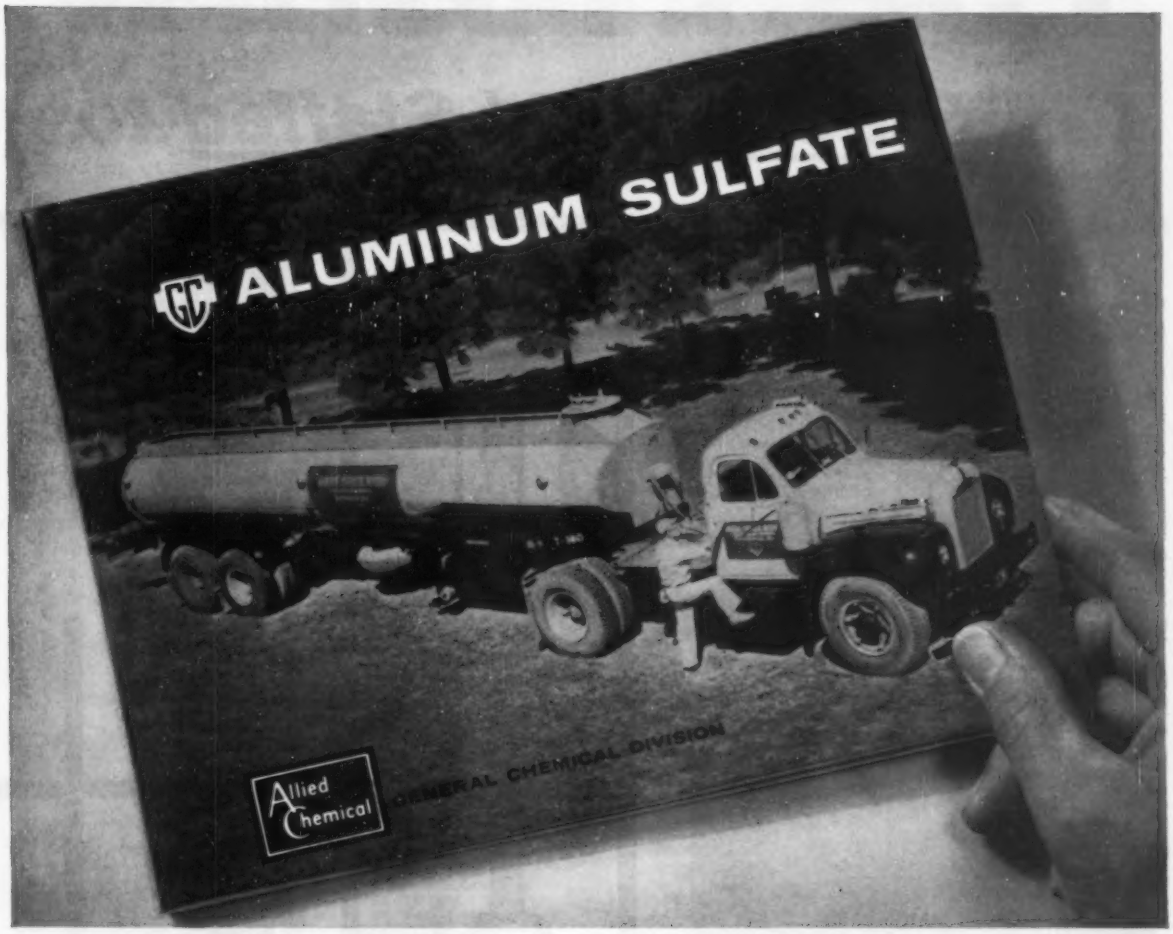

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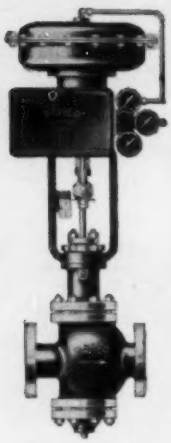
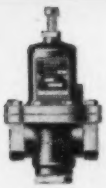


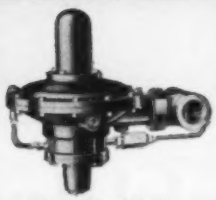
Type 657-A with 3500 Positioner

Type 4150 and 4160 Wizard II Pressure Controllers

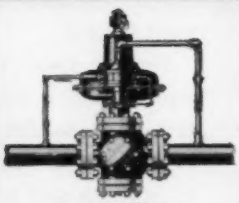


Type 95-H Pressure Reducing Valve

Type 630 "Big Joe" Field Regulator



Series 99-I Multi-Purpose Gas Regulators



Series 298T Gas Regulators

Type 655-A Pressure Regulator

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

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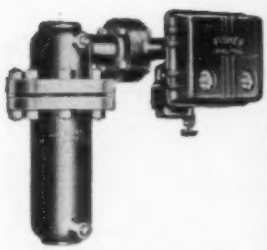
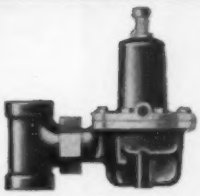
"Supermarket"

give 36 hour Factory service!



Series 2500-249 and
2500-259B
Level-trols
Cage Sizes 14" and 32"



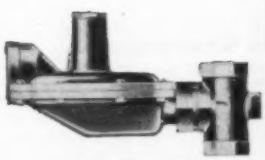
Series 620 and 621
Farm Tap Regulators

Series 67FR Combination Filter Regulator

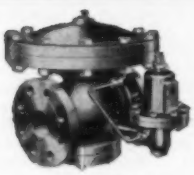
Yes, now you can shop by phone, wire or TWX (Marshalltown 578 or 579) and expect shipment of the equipment illustrated at left in a matter of hours. Now that Fisher Control Valves and Regulators are as readily available as your supermarket groceries, you can meet your emergency needs quickly. Fisher carries a stock of the popular and standard size control valves, displacement type liquid level controllers, pressure regulators and gas regulators on the "supermarket" shelf at all times. The offices in red maintain a wide selection of Fisher equipment in their own inventory.

New items will be added from time to time as needed. Each Fisher representative receives a weekly list of all available types and sizes.

Now, for emergency needs contact either the Fisher representative or the Fisher home office. Your order will be en route within 36 hours (except Saturday and Sunday) after it is received in Marshalltown.



Series S100 and 730
Service Regulators



Type 92B Pilot
Operated Steam
Reducing Valve

AMARILLO
Vinson Supply Company
ATLANTA
J. M. Smither & Company
BALTIMORE
The Rhodes Controls Company
BIRMINGHAM
Joseph W. Eshelman & Company
BOSTON
Clarence B. Petty & Company
BUFFALO
W. J. Sommers Company
CALGARY-EDMONTON
Barber Engineering & Supply Company
CARACAS, VENEZUELA
Sinclair Spence
CHARLOTTE
Robert E. Mason & Company
CHICAGO
General Meters & Controls Company
CINCINNATI
H. T. Porter Company
CLEVELAND
A. E. Ehrke & Company
DALLAS
Vinson Supply Company
DENVER
Joy & Cox, Inc.
DETROIT
DuBois-Webb Company
HOUSTON-CORPUS CHRISTI
Puffer-Sweiven Company
INDIANAPOLIS
Acme Engineering Agency
KANSAS CITY
Sullivan-Mears Company
LOS ANGELES
B. R. Jones & Company
LOUISVILLE
Allan K. Cook Company
MARSHALLTOWN
E. S. Stover Company
MEMPHIS
Johnson & Scott
MEXICO, D. F.
Babcock & Wilcox de Mexico
MILWAUKEE
W. D. Ehrke & Company
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R. G. Read & Company
MONTREAL
Process & Steam Specialties, Inc.
NEW ORLEANS-LAFAYETTE
John H. Carter Company
NEW YORK
Crabbe & Stebbins Company
ODESSA-FARMINGTON
Vinson Supply Company
PHILADELPHIA
Clifford B. Ives & Company
PHOENIX
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TORONTO
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TULSA
Vinson Supply Company
VANCOUVER
Northern Columbia Process Equipment Company
WICHITA-LIBERAL
Sullivan-Mears Company
WINNIPEG
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Offices listed in red maintain field stock.

FISHER® Controls
SINCE 1880

FISHER GOVERNOR COMPANY
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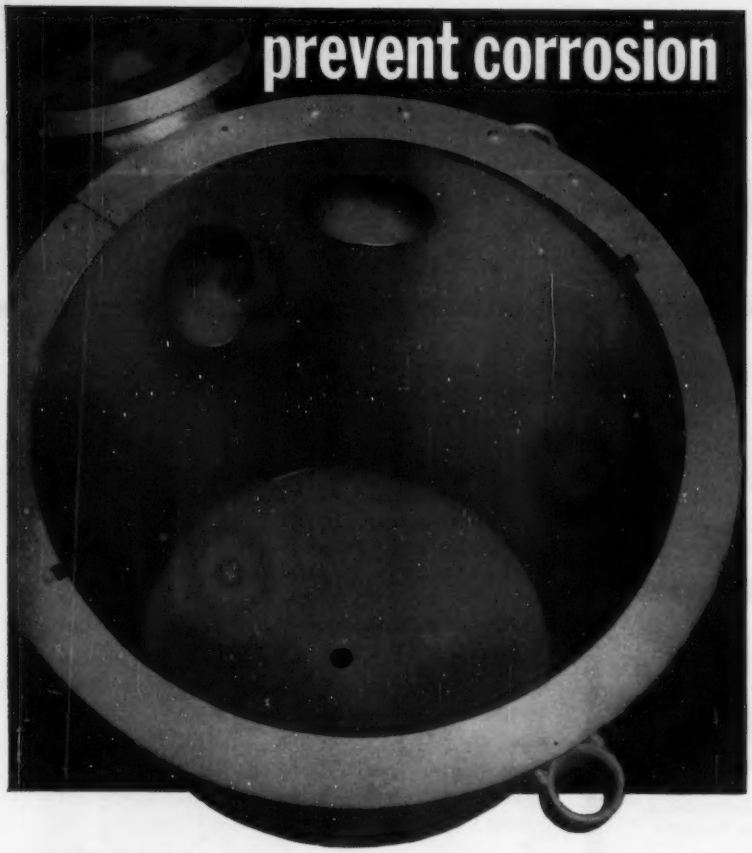


...with CHEMISEAL® Fluorocarbon Plastic linings

From a reactor pot to a tank truck—Chemiseal Fluorocarbon Plastic linings, offer the way to make any ordinary equipment and piping extremely resistant to acids, alkalies, oxidants and solvents at temperatures up to 350°F—and at reasonable cost.

Chemiseal Fluorocarbon Plastic sheet, Garlock No. 9574, is durable, shatterproof, abrasion resistant, chemically inert. It is readily cemented over any contour and to any material of construction—metal, wood, concrete, etc. Being a thermoplastic resin, seams may be "welded", on the job by the thermal pulse technique, into a continuous chemically-impregnable lining.

CERTIFIED APPLICATORS—Chemiseal Fluorocarbon Plastic lining material is available for installation by the following certified applicators.

Atlas Metal Protection, Inc., Houston, Texas
The Barber-Webb Company, Inc., Los Angeles, Cal.
Belke Mfg. Co., Inc., Chicago, Ill.
Buckley Iron Works, Dorchester, Mass.
Electro-Chemical Engrg. & Mfg. Co., Emmaus, Pa.
Metalweld, Inc., Philadelphia, Pa.

Write for Bulletin AD-152.

Special Products Department
UNITED STATES GASKET COMPANY
Camden 1, New Jersey

United States Gasket — Plastics Division of GARLOCK

The Mail Box . . .

Revises Equations

To The Editor:

V. O. Marshall's "Foundation Design of Stacks & Towers" in your May issue is a highly valuable design guide for petroleum industry.

However, a few equations in that article, such as (53), (54), (37a), (37b) and (37c), seem to be in error or incomplete.

For towers with one set of guyed wires, the maximum moments at collar and between collar and base should be calculated as follows:

$$M_c = -\frac{P_w}{2H}(H - h_1)^2 \qquad (53)$$

$$M_p = \frac{P_w H}{2}\left(1 - \frac{H}{2h_1}\right)^2 \qquad (54)$$

The bearing stress of the concrete should be checked under operating condition (worst case). Therefore eqs (37a), (37b) and (37c) should be rewritten as follows:

Bearing stress

$$4M_t/\pi D_1^2 + (W_s + W_s)/\pi D_1 \qquad (37a)$$

$$f_b = \frac{\dfrac{4M_t}{\pi D_1^2} + \dfrac{W_s + W_s}{\pi D_1}}{12r_w} \qquad (37b)$$

$$f_b = \frac{\dfrac{4M_t}{\pi D_1^2} + \dfrac{R_v + W_s + W_s}{\pi D_1}}{12r_w} \qquad (37c)$$

This is for your information. I would appreciate your comment or a comment from the author of the article.

Tsung Cheng Tu

Los Angeles

Suggests Changes

To The Editor.

As a structural engineer, I have been very interested in the article by V. O. Marshall on "The Design of Foundations for Stacks and Towers," as published in August, 1943. It is very useful and I was glad to see it revised and reprinted in May, 1958.

I was disappointed to find, even though it had been rearranged into a better form, that it was not revised up to date to agree with the latest ACI Building Code. For years, the allowable compression stress has been 45 percent of the strength of the concrete. About 1950, the deformations on the reinforcing bars were changed and the allowable bond stresses were revised.

During the revising of the article, the values in Table 2 should have been revised to agree with the new values, as shown in Table 305 (a) of the latest ACI Building Code.

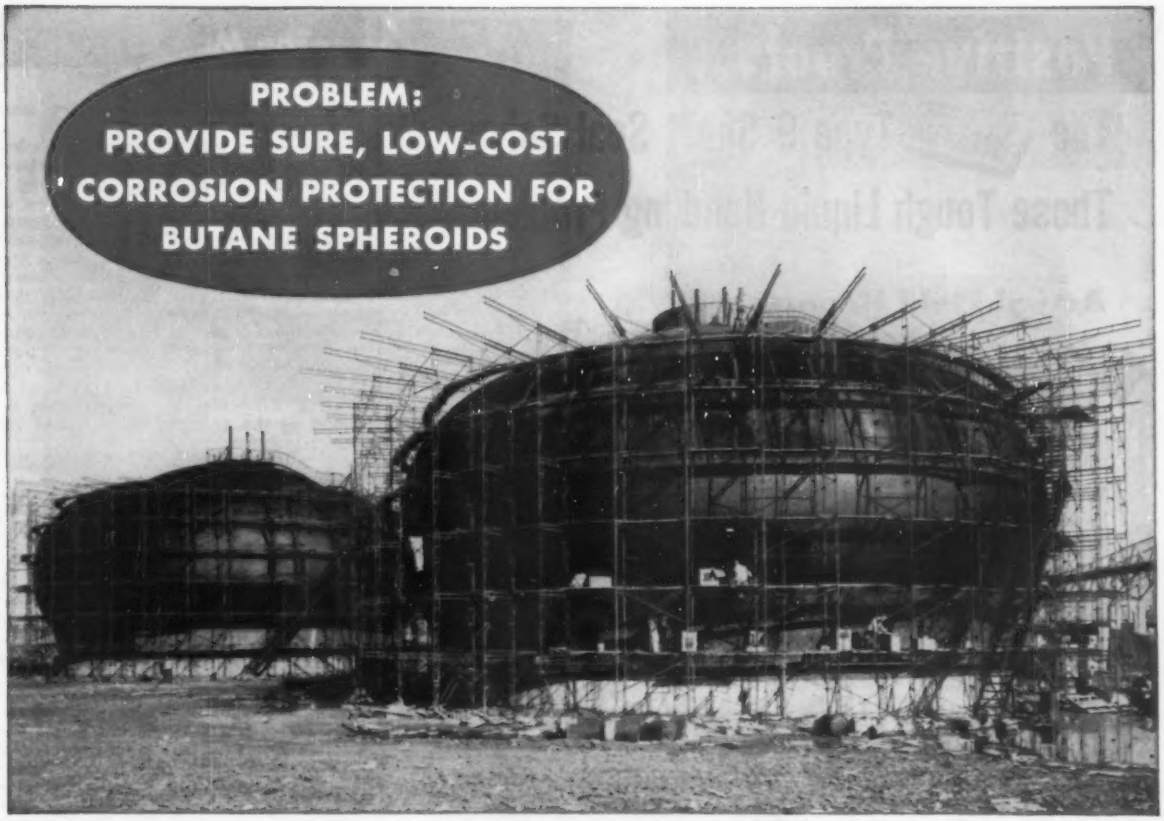
Henry A. Traue

Bartlesville, Okla.

Author's Comment

With reference to the letter from Mr. Tsung Cheng Tu dated May 29, in which he proposes revisions in equations 37a, 37b, 37c, 53 and 54 of my article on foundations, my comment is that all of these revisions are obviously correct. The work sheets used in the development of this material have long since been lost, so

For more data on advertised products, use Readers' Service Cards, last page.



Solution: Specify Time-Tested PITT CHEM *Insul-Mastic*

SELECTION of a durable, heavy-duty moisture and vapor seal was an important consideration in planning the corrosion and insulation protection of five 40,000-barrel spheroid butane tanks at a large East Coast refinery.*

Because of its long record of maintenance-free service in the petroleum industry, Pitt Chem *Insul-Mastic* Gilsonite coating was specified for the job. Foam glass type insulation blocks were imbedded in *Insul-Mastic* #4010 Vaporseal. The same material was used for all joints and sprayed as a final weather sealing coat to protect the efficiency of the insulation and prevent corrosion of the metal structures. A glass membrane was imbedded in the weather sealing coat to assist in withstanding structural movement. Geo. V. Hamilton, Inc., Pittsburgh, was contractor for the job.

Pitt Chem *Insul-Mastic* coatings have no equal in stopping moisture vapor penetration. Unlike ordinary asphaltic coatings, they contain *Gilsonite*, one of the most chemically resistant bitumens known. They withstand extremes of heat and cold, moisture and dryness, expansion and contraction.

Specify Pitt Chem *Insul-Mastic* for *your* next corrosion-proofing or vapor sealing job. You'll be using the same protection applied to many hundreds of pieces of equipment in the petroleum industry, many of which have been *Insul-Mastic*-protected for nearly two decades with little or no maintenance cost.

Pitt Chem *Insul-Mastic* Coatings are available through your local industrial distributor. Call him today for more information, or write direct for a Pitt Chem Corrosion Protection Guide.

*Name on request.

Think First of the Coatings that Last!

PITT CHEM
Coal Tar Coatings

PITT CHEM
"Insul-Mastic" Gilsonite Coatings

PITT CHEM
"Tarset" Coal Tar Epoxy Coating

PITT CHEM Industrial Coatings are available through leading Industrial Distributors. See the "Yellow Pages."

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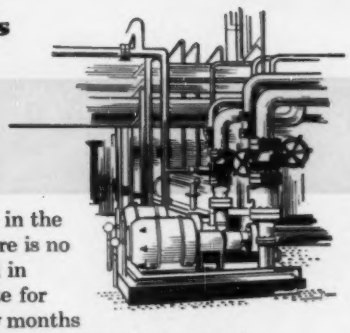
Positive Proof...

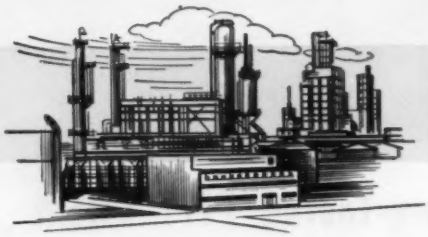
The John Crane® Type 9 Shaft Seal Solves Those Tough Liquid Handling Problems

Actual Field Reports



✓ from an Arkansas Refining Plant

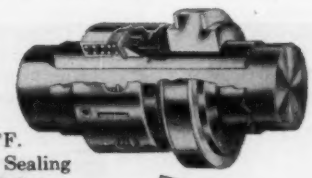
When it comes to avoiding trouble in the handling of naphtha at 420°F., there is no substitute for positive sealing. And in cases like this there is no substitute for "John Crane's" Type 9 Seal. Many months of completely satisfactory operation offers convincing proof.



✓ from a Louisiana Refinery

It takes a "lot of shaft seal" to handle a highly corrosive mixture such as an emulsion of sulphuric acid and butane. This stuff plays real havoc with metals due to its corrosive action. Despite this, Type 9 Seals on twenty seven pumps are pumping month after month in continuous service. At this same location, other Type 9's are effectively handling "fresh" sulphuric acid at the high suction pressure of 400 psi.

In cases like these . . . and in those confronting you . . . the surest answer is the "John Crane" Type 9 Seal.



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Recommended services: all industrial chemicals, corrosives, liquids or gases. Temperatures: −120°F. to +500°F. Pressures: up to 750 psi. Construction: Sealing members of chemically inert DuPont Teflon, metallurgy best suited to service requirements.

Send us your problems. Request Bulletin S-205-2.

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John Crane — MECHANICAL PACKINGS · SHAFT SEALS · TEFLON PRODUCTS · LAPPING MACHINES · THREAD COMPOUNDS

CRANE PACKING COMPANY

The Mail Box . . .

we'll never know how or where these errors crept in.

Referring to Mr. Henry A. Traue's letter dated May 27, it probably would have been better to revise Table 2 to bring it into agreement with the latest edition of the ACI Building Code, as he suggests. However, the strength of concrete varies widely, even under ACI rules, depending upon exactly which grade is being used. Then, there is always the possibility that local regulations may enter the picture, as this material is used in many foreign countries as well as in widely scattered sections of the United States. It seems to me that Table 2 must necessarily be considered as a guide, subject to the modifications required by the grade of concrete and the local regulations.

V. O. Marshall

Kingsport, Tenn.

Sees No Shortage

To The Editor:

PETROLEUM REFINER is certainly to be congratulated for its article on the engineering shortage in the June issue (Page 121). Please convey my thanks and enthusiasm to Drs. W. A. Cunningham and John J. McKetta.

The authors of the article have certainly pointed out in a subtle fashion the irresponsibility of persons, who in the immediate past have been crying a shortage of scientific personnel. It is not surprising that many of the people who have been crying "wolf" in the past were large corporations. However, the point that is very sad is that many of our technical societies have been crying "wolf" louder than anyone else. Perhaps the immediate sobering circumstances will give food for thought to our engineering societies. We may well all consider the possibilities of striving towards making the Engineering Joint Council into a sort of AMA or ABA.

Again, let me be one of the many who I am sure are expressing gratitude for your article concerning the engineering shortage. This is the type of article that should be publicized in magazines other than our technical journal.

A. D. Scotty, Jr.

Houston.

To Distribute Editorial

To The Editor:

I was extremely interested in the Cunningham-McKetta editorial in the "Lookbox" feature of the June, 1958 issue of PETROLEUM REFINER (Page 121). As chairman of the Subcommittee on Information (Career Guidance Committee) of the American Institute of Chemical Engineers, I should like to disseminate this editorial to the committee at large.

Hamarville, Pa. B. J. Lerner

Bean Not Ch.E.

Theron W. Bean, author of "What Does a Refinery Estimate Cost" (PETROLEUM REFINER, July, 1958) has called our attention to an error in his biography which appeared on page 166 of the July issue. We inadvertently changed his profession by calling him a registered chemical engineer, when in fact he is a mechanical engineer.

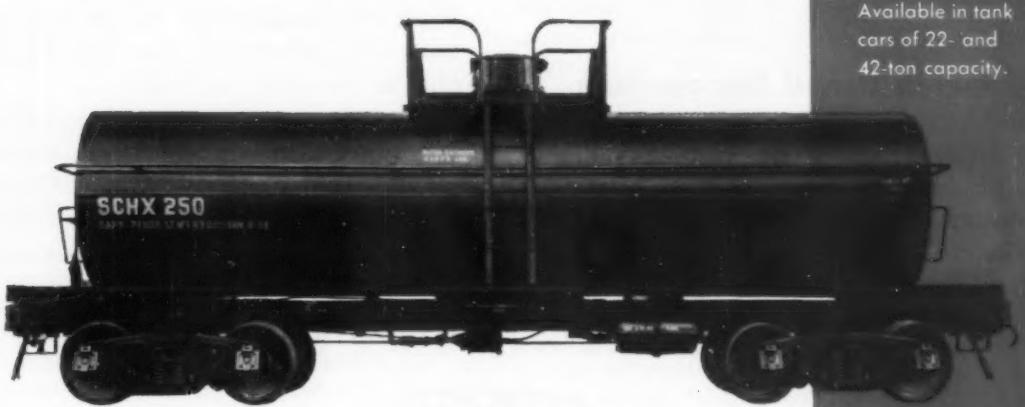
The Editor

HF

HYDROFLUORIC ACID

anhydrous and aqueous

STAUFFER HAS IT...
IN QUANTITY AND QUALITY



Available in tank cars of 22- and 42-ton capacity.

STAUFFER CHEMICAL COMPANY

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NYOTEX CHEMICAL DIVISION, P. O. Box 9716, Houston 15, Tex.

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The several uses of COLOR
IN PETROLEUM PRODUCTS

Kerosine, heating oils, tractor and diesel fuels, lubricating oils and greases

THE UNIVERSAL use of dyes for gasoline, of course, is to denote that it contains tetraethyl lead.

However, in recent years many refiners have become increasingly color conscious, and dyes are now used in many types of petroleum products—kerosine, home-heating oils, tractor and diesel fuels, and lubricating oils and greases.

This trend has been due partially to industry appreciation of its merchandising value.

Builds Brand Recognition

Brand identification through color can provide an important sales advantage in almost any product you make. This has been demonstrated by a number of motor oil and grease marketers. Color can help promote your heating and diesel fuels, too.

Grade identification and leak detection are still other important qualities that color provides.

Selecting the right color for your product is a relatively simple matter, when you take advantage of Du Pont's over-all experience in the world of color. Since 1916, Du Pont has been a leader in the research and manufacture of dyes, covering a broad range of product categories. Textiles, paints, plastics, photographic film are but a few.

Color Assistance for you

With this background, we can give you the most comprehensive color assistance available in the additives field.

First step to get this help is to call in your Du Pont Petroleum Chemicals Division representative to discuss your need. Or write direct to E. I. DU PONT DE NEMOURS & Co., (INC.), Petroleum Chemicals Division, Wilmington 98, Delaware.

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING...*THROUGH CHEMISTRY*

Petroleum Colors

. . . it's more than a week-a-year job!

ALMOST BEFORE WE KNOW IT (October 12-18) we will be observing Oil Progress Week—those seven important days when our industry makes special effort to tell its story to the public. This year the theme is "TODAY—OIL BUILDS For Your TOMORROW" and right now it's time for individuals, organizations and companies within the industry to start planning the way to make the oil story most effective as it is told to the world.

The 1958 theme will encourage Oil Progress Week participants to relate petroleum's story of steady growth and noteworthy accomplishments in terms of what it means today and what it will mean in 1964 to the children now entering grade school. For example, an illustration of a six-year-old boy and girl looking into the world of the future will be used extensively.

Relating the oil business to the future needs of children is probably the best way for our industry to explain to the general public that ours is an industry that recognizes its responsibility; an industry which will continue meeting the needs of a rapidly expanding U. S. and other countries; an industry which will work untiringly to fulfill that responsibility.

Be Prepared. As individuals, we can help by getting a good grasp of oil industry facts and thus be prepared to tell our friends and neighbors just what our industry has done and plans to do. For instance, you might be interested in knowing that by the time 1965 gets here, we will be supplying oil products for 18 million more people and 14 million more cars. In preparation for this terrific increase, it has been estimated that the oil industry will have to invest $80 billion in production, plants and equipment.

Organizations and companies can help too by planning special oil displays in areas and locations where they will be available for public inspection; by scheduling an Oil Progress Week story in their company newspapers and publications; by planning to make available information which will inform employes about the purpose and theme of Oil Progress Week. A good example of this last point is the special employe leaflet, "Another Opportunity to Speak Up for Your Industry," which is available in quantity through the API. Undoubtedly, some companies plan to attach one of these leaflets to each employe's pay check or pay envelope.

Yes, our industry faces the gigantic task of supplying this great nation and the world with its oil and gas needs. In the past we've met this challenge on a continuous basis. During Oil Progress Week from October 12 to 18, we of the oil industry can and should stand tall and be proud to tell the world our industrial performance in the future will be equally as notable.

Careful Planning, Please. Of course, being ready for tomorrow and tomorrow's tomorrow requires more than idle dreaming or eleventh-hour planning. And in this respect the oil industry's record is outstanding. It represents years of skilled management and knowhow plus remarkable foresight *and* the courage at all times to back its belief in the future with huge financial outlays. Truly, the oil industry stands ready today, as the slogan says, to help build the world's tomorrow. It has a record of remarkable achievement and a future just as bright. So—

In addition to setting up plans that will take advantage of the intensive promotion attending Oil Progress Week, resolve to do a bit of personal missionary work every day in the year in behalf of our great industry. Its record justifies a lot more prideful pointing to than either oil men as individuals or as company officials seem ever to give it. And if ever there was a business that needs the truth told and retold about it—this in order to counteract the plague of unfavorable propaganda that seemingly always is with us—it is this oil industry of ours.

Plan now to do your part during Oil Progress Week, but both before and after resolve to be active in the badly needed job of helping to gain public esteem by the simple procedure of proclaiming pertinent oil industry facts at every opportunity.

The oil industry cannot speak, but you can!

Another Boom For Ammonia?

AN 80 PERCENT INCREASE in the manufacturing capacity for synthetic ammonia—at a cost of $450 million—will be needed by 1975 in order to meet farm and industrial demands.

This is the estimate of Ford, Bacon & Davis, Inc.,

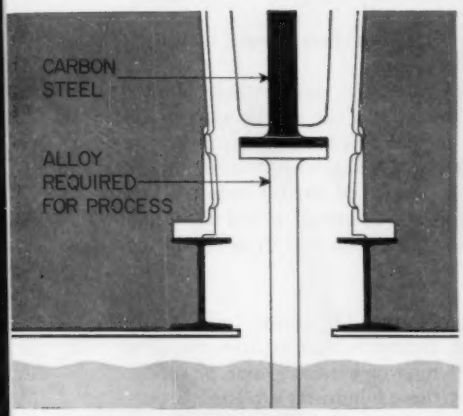
If you want to cut fluid mixing costs
look inside the tank

You can make some of your biggest cost reductions *inside* the tank, when you select a mechanical mixer for fluids.

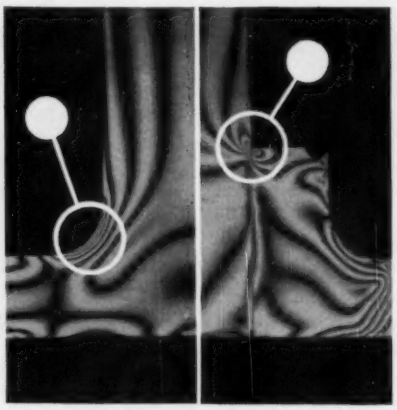
These are *long-term* savings—based on low-cost maintenance, trouble-free service, adaptability to changes in your process, minimum spare-part requirements.

These are the areas where you can *really* save money on fluid mixing. And here are some in-the-tank reasons why you can do it better with LIGHTNIN Mixers than with any other make. For lowest-cost fluid mixing, see your LIGHTNIN representative soon. He's listed in Chemical Engineering Catalog. Or write us direct.

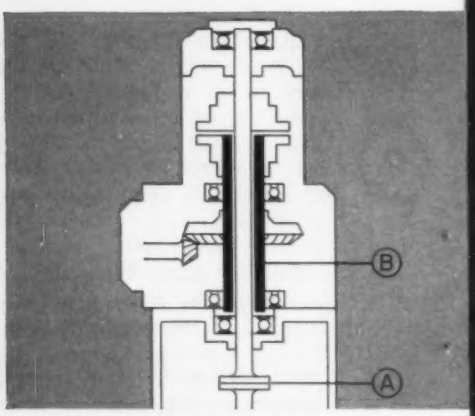
Save 6 ways with these *Lightnin* shaft and impeller refinements



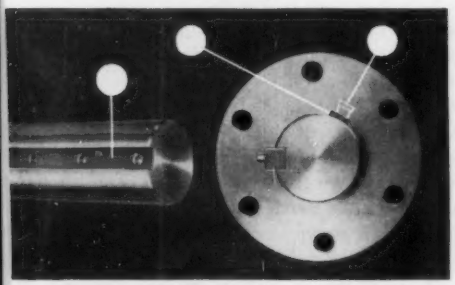
1. Get lower-cost installation, upkeep with two-piece shaft. Standard on open-tank units (available with closed-tank units, too), lower section is alloy required for process; upper section can be inexpensive carbon steel. Rigid coupling has rabbeted joint assuring accurate alignment.



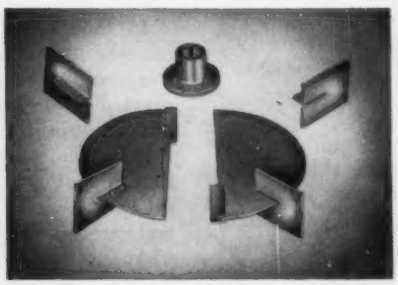
2. You get twice the strength of conventional shaft couplings with LIGHTNIN deep-welded coupling (A). Not one of these couplings has ever failed in service. Polarized light shows how machined and polished radius eliminates stress concentration found in conventional coupling (B).



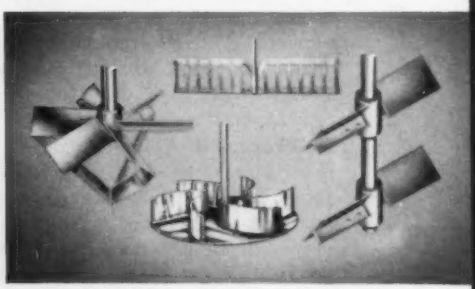
3. No need to disturb gearing if you ever want to replace a LIGHTNIN shaft. Lower shaft is unbolted at (A). Upper shaft slides out of hollow reducer quill* (B). Gears remain untouched—cannot get out of line. When new shaft is installed, shaft alignment is automatic. *Patented



4. Save time positioning impellers. Standard 18-inch shaft keyway (A) provides seven positions (more if you want)—saves you cost of special machining. Also note shallow extra keyway (B) for impeller hub setscrew (C). It permits impeller to slide freely, even if shaft is burred.



5. Cut impeller replacement cost with LIGHTNIN all-bolted design. Replace blades without buying a whole new impeller. Blades come off to pass small openings; or impeller can be supplied split, as shown. Same disc takes 4, 5, 6, or 8 blades for easy change in power input.



6. Get the right impeller for your needs. You can handle practically any fluid mixing requirement with a standard LIGHTNIN impeller. But for special jobs, you can get LIGHTNIN impellers made to specification in all machinable materials and with widest choice of coverings.

WHAT MIXING OPERATIONS ARE IMPORTANT TO YOU? You'll find a wealth of information on fluid mixing in these helpful bulletins describing LIGHTNIN Mixers:

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- ☐ Portable: ⅛ to 3 HP (B-108)
- ☐ Confidential data sheet for figuring your mixer requirements (B-107)
- ☐ Side entering: 1 to 25 HP (B-104)
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MIXCO fluid mixing specialists

whose vice president R. P. Westerhoff recently pointed out that existing ammonia capacity, valued at some $500 million, totals about 10 billion pounds a year with consumption nearing current production. He said that ammonia is already at the head of the petrochemical industry and "bids well to outdistance its own swift postwar growth."

Soil enrichment alone could pre-empt existing ammonia capacity in a few years and in addition to some 8 billion pounds of new capacity for predictable agricultural and industrial uses, some $50 million worth of extra capacity will have to be built concurrently to meet demands for ammonium nitrate as an explosive, Westerhoff declared. For controlled blasting the 1956 figure of 300,000 tons will have to be tripled by 1975.

America averaged only two pounds of nitrogen fertilizer per acre in 1940 but this jumped to 10 by 1955. Now the estimate, if the present rate of increase in feeding the soil is maintained, is that national average will double to about 20 pounds by 1975. Europe uses this fertilizer in much greater quantities, the per-acre average running as high as 156 in The Netherlands, 84 in Belgium, 46 in West Germany, 38 in Norway and 31 in United Kingdom. Exports are expected to increase 200 percent by 1975.

Ammonia is manufactured by combining atmospheric nitrogen and manufactured hydrogen. Petrochemically, the hydrogen is derived from natural gas. With natural gas selling at 20-30 cents per MCF, ammonia can be produced for about $30-$40 per ton. The selling price of ammonia today is approximately $88 per ton.

Just Plain Good Business

A MAJORITY of the more than 1,000 physically handicapped employes of E. I. du Pont de Nemours & Co. have achieved average-or-better levels of job performance, safety and attendance. Proving once again that "it's good business to hire the handicapped."

Moreover, it appears that the nature of the handicap is not a particular factor as some of the best performers have the most severe handicaps—amputation, blindness, deafness and even paraplegia.

Until a few years back the individual who was seriously handicapped physically had little opportunity for employment. That there has been a complete about-face in this situation is a definite tribute to the sound management policies of some of the country's largest and most far-sighted companies.

Actually Du Pont had no firm policy of hiring the handicapped until October, 1954. This came in line with the President's Committee on Employment of the Physically Handicapped and its counterparts, the Governor's Committee in each of the 48 states. Now every firm in the United States may work with its governor's committee and the United States Employment Service. Those organizations keep track of all known job possibilities and applicants.

At Du Pont, operators comprise the largest segment of the handicapped with 258; following closely are craftsmen and foremen with 255. Professional and technical jobs total 163; service workers 145; clerical 131; supervisory and management 43; and laborers 26.

The safety record of this group shows that 39 percent were better than average, 59 percent average and only 2 percent below average. In attendance, 36 percent were better than average, half were average, and 14 percent below average. In job performance 27 percent were above average, 6 percent average, and only 13 percent below the norm.

These figures mean one thing—satisfactory employe production for each salary dollar spent. Companies who haven't devoted time or thought to the subject should take heed and realize that hiring the handicapped actually is good business.

Politics, Not Justice

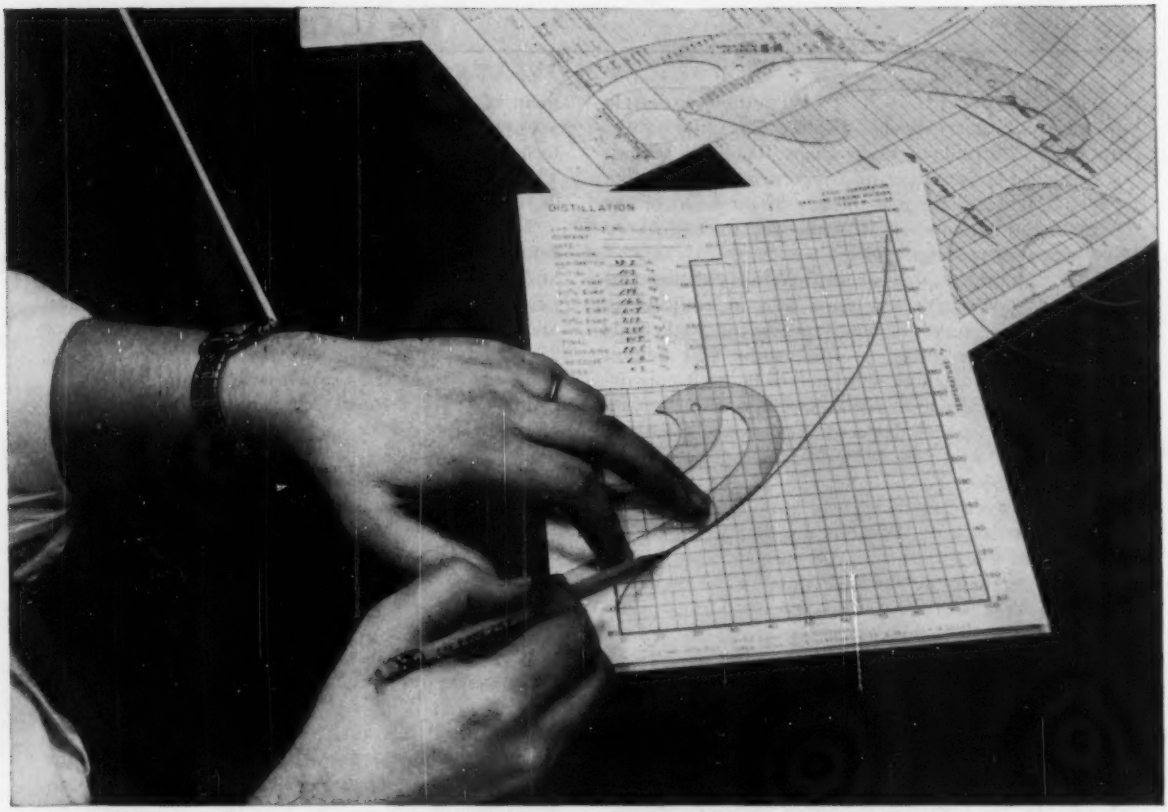
WHEN THE SUEZ CANAL was closed, oil companies of the U. S. responded to a call from President Eisenhower and through extraordinary effort kept our Western Europe allies supplied with petroleum. In "gratitude" for this action, 29 companies are plastered with a conspiracy charge.

The indictment, deliberately or not, ignores the basic law of supply and demand which a free business economy has a right to expect. Total demand for U. S. oil rose from 8.7 million barrels per day in September, 1956 to 11.4 million barrels in January, 57. During this period exports to Europe increased from 350,000 to slightly more than 1 million barrels daily. Wasn't it expected that prices would increase under such demand pressure? (When Suez was reopened gasoline prices tumbled with a lowered demand, but the Virginia grand jury conveniently did not extend its investigation past January, 1957.)

Business, and this is especially true of oil, has come to expect Washington to kick it on the shins with regularity. These cases show up with such frequency that truly there is danger that the American free enterprise system is being softened up for the socialistic kill. Is that what Washington wants—complete destruction of the American way of life?

Politics should not be placed above maintaining a healthy national economy. Ripping business apart in the eyes of the public is bound to stifle the flow of investor money needed for expansions as our population grows. These attacks—and how frequent!—also do damage in that they distract management from regular business affairs. Think what forward steps might have been taken if all of oil's courtroom and congressional committeeroom hours had been devoted to out-and-out business planning!

Oil will defend itself, of course. And its defense will be an able one. But shame on a government that encourages unnecessary attacks on an industry just because the political wind comes from a certain direction. For a change, especially during these trying days, Washington should try devoting its power to more constructive matters.



Distillation data and octane number data must be tabulated before machine calculations can be made to determine blending properties. Here, data are plotted for fuel blends in various combinations so that intermediate property points can be read.

Ethyl Research Advances the Application of Electronic Computers in Refinery Technology

By Dr. W. C. Healy, Jr.,

Supervisor of the Mathematical Analysis Section,
Refinery Technology Division, Ethyl Research Laboratories

DURING the past three years, the use of electronic digital computers has experienced tremendous growth within the refining industry.

Each new application in this field has been part of an over-all effort to develop the most practical mathematical approach and machine computing technique. Once this is accomplished, the solution of similar complex problems becomes more routine.

A New Section for Computer Study

Ethyl Corporation, the leading manufacturer of tetraethyllead, is vitally concerned with means of achieving most effective use of "Ethyl" antiknock compounds.

Studies of fuel composition, road performance, and octane improvement economics have for many years been a direct result of this philosophy.

Using past experience, the scope of studies by our Detroit Refinery Technology group has been broadened by the formation of a Mathematical Analysis Section to advance electronic computer application.

Field of Investigation

The major technical computer applications which have been studied to date are:

1. Computations of the properties of gasoline blends.
2. Analysis of road test data.
3. Processing of data from tetraethyllead and octane cost surveys.
4. Determination of best allocation of gasoline blending stocks and tetraethyllead.
5. Analysis of refining process operations related to tetraethyllead use; e.g., reforming.

An extensive computer effort has been the determination of best allocation of gasoline blending stocks and tetraethyllead (Item 4), a field of direct interest to those dealing with refinery operation.

For more data on advertised products, use Readers' Service Cards, last page.

Scope and Mathematical Approach

An example refinery running 50,000 barrels crude per day might market several finished grades of gasoline blended from perhaps twice as many refinery streams. A blending problem from this refining situation could consist of as many as 100 equations with perhaps twice as many unknowns.

In the past, this problem of optimizing an operation, while satisfying many restrictions, has been a difficult one and is necessarily limited by the magnitude of computing facilities. However, one form of optimization problem, known as linear programming, can be solved by repetitive simple arithmetic operations.

The basic process is known as the simplex method.

Large-scale, high-speed computing machinery has made linear programming an attractive means of arriving at the best solution of blending problems, even though linear approximations to some blending calculations are necessary.

A requirement of this method is the availability of constant blending values.

One approach to determine good blending values is to use the technique of least squares with component percentages as independent variables. For each property, e.g., Motor Octane Number @ 3.0 ml. TEL-gallon, an equation is determined by least squares as follows:

$$Y = X_1 B_1 + X_2 B_2 \ldots\ldots\ldots + X_n B_n$$

where:

Y = value of blend property

$X_1, X_2 \ldots X_n$ are component proportions by volume

$B_1, B_2 \ldots B_n$ are blending values being determined

Stepwise Solution of the Blending Problem

The usual first step in a computer blending study to optimize blending economics is to perform a series of laboratory blending tests. Such tests provide data for computation of blend properties and also verify computed properties.

These specifications or blend properties then can be expressed mathematically:

Reid Vapor Pressure

Volatility (specified by Distillation)

Research Octane Number

Motor Octane Number

Material Balance

Since the final objective is to achieve maximum dollar profit from the blending operation, economic features must be mathematically expressed as part of the total problem. A minimum list of economic factors ordinarily considered and incorporated in the study are:

Tetraethyllead

Alternate use values for components with more than one disposition

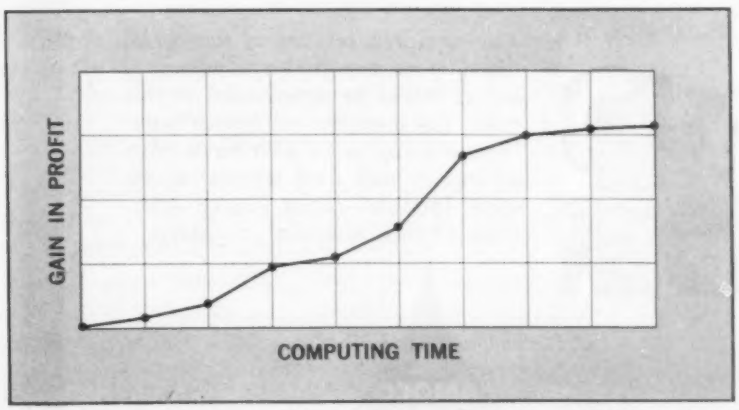
"Net Back" values on products which can vary in quantity.

After equations have been formulated, extensive tabulation is necessary to record equation coefficients on computer data sheets. Following this, all data are key punched on computer cards.

Proofreading is continuous, since a single incorrect sign or coefficient can throw off the whole computation.

Once data preparation and card punching are complete, cases of increasing profit to the refiner are generated on a large, high-speed computer. A study might entail generation of several hundred solutions.

Final solutions are analyzed and interpreted. A few of the better solutions are checked with actual laboratory blends. Following this, the end results are reviewed by process engineers for application to refinery blending.



Ordinarily computer time is used until further increase in profit is negligible. Shown above is a sample plot of gain in profit vs. computer time.

How Ethyl Research is helping you

The formation of a Mathematical Analysis Section in Ethyl's Refinery Technology Division is another step toward most effective use of "Ethyl" antiknock compounds by the oil industry.

This new group of specialists will be glad to share its experience in computation techniques with your people.

For further information, call your Ethyl Representative. He will be glad to arrange an appointment for you with one of our Refinery Technologists.

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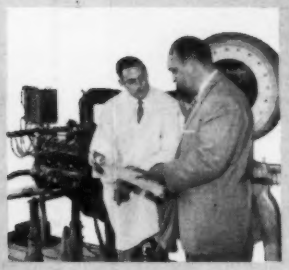

The complex science of motor oil blending requires that men who market additives be experienced in this work. The men who sell Amoco Additives are engineers who have both laboratory and field service experience. Inquiries about Amoco Additives get their immediate attention.

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How Inflation Affects Cost Analysis

Here's how inflation enters into cost analyses by the capitalized cost method. Provision for income tax also is considered.

F. C. Jelen
Solvay Process Division, Allied Chemical Corporation, Syracuse, N. Y.

IN THE PAST, engineering cost comparisons have always been made on the basis of a dollar of constant quality. Such a condition, however, is no longer valid and it has become an axiom that the dollar decays from year to year. The engineer must recognize it and treat the dollar as a variable. This article shows how to accommodate inflation in comparative cost analyses and allows for the inclusion of income tax as well.

An earlier article[2] which included inflation along with taxes was based mainly on capitalized cost as a method for making the comparisons, but indicated also how the comparisons could be made on the basis of an annual cost. The analysis here will be chiefly on an annual cost basis. An excellent presentation of the Annual Cost method has been given by Grant[1] but without consideration of the inflation aspect.

It is not the intention here to predict the course of inflation, but merely to show how to include any assumed inflation rate in the calculation. The inflation rate per year is denoted by d expressed as a decimal. The interpretation means simply that if an item costs C dollars now, it will cost $C(1+d)$ one year from today, $C(1+d)^2$ two years from today and so forth.

Annual Cost. Before proceeding to the inclusion of inflation it will be instructive to examine the Annual Cost method without inflation.

The Annual Cost method uses the *end* of the year for the time instant to which the annual cost is referred. If an article costs $10,000, lasts one year, and money is worth 8 percent per year the annual cost is $10,800:

$$10{,}000\ (1.08) = \$10{,}800.$$

That is, $10,800 at the end of the year will repay exactly with interest at 8 percent per year an expenditure of $10,000 at the beginning of the year. The annual cost of the $10,000 article lasting one year is $10,800. Note further that the annual cost remains $10,800 for all the years that the article is replaced in kind.

How much can we afford for an article that lasts three years which is equal economically to the above?

If the one year article is purchased three times so as to get three years use, the cumulative cost as of the end of the three years is:

$$10{,}800(1.08)^2 + 10{,}800(1.08)^1 + 10{,}800(1.08)^0 = \$35{,}600.$$

Let the three-year article cost C dollars. If it is to have an annual cost of $10,800 so as to be equal economically to the one year article, the cost as of the end of three years must likewise be $35,060. This gives

$$C(1.08)^3 = 35{,}060$$
$$C = \$27{,}832.$$

That is $27,832 could be spent now for an article that lasts three years. Note that the annual cost of this article is $10,800 if money is worth 8 percent per year.

For the purpose at hand it is most instructive to regard the annual cost as the end-of-year cost of an article that lasts one year.

A cost is given a positive designation throughout this presentation while a receipt will be negative.

Add Inflation. Suppose an inflation rate of 4 percent per year is to be considered in the preceding illustration.

The one year article can be purchased now for $10,000 which is equivalent to $10,800 as of the end of the first year. A replacement one year hence will cost $10{,}000(1.04) = \$10{,}400$ which will be equivalent to $10{,}400(1.08) = \$11{,}232$ as of the end of the second year. The next replacement will cost $10{,}000(1.04)^2 = \$10{,}816$ which will be equivalent to $10{,}816(1.08) = \$11{,}681$ as of the end of the third year.

If the one year article is purchased three times so as to get three years use, the cumulative cost as of the end of three years is

$$10{,}800(1.08)^2 + 11{,}232(1.08)^1 + 11{,}681(1.08)^0 = \$36{,}405.$$

Let the three year article cost C dollars now. For equal economy it likewise should represent a cost of $36,405 as of the end of three years. This gives

$$C(1.08)^3 = 36{,}405$$
$$C = \$28{,}893.$$

Up to $28,893 can be spent now for the three-year article if the inflation rate is 4 percent per year. It was found previously that only $27,832 could be spent when inflation is absent. Thus the effect of inflation is to add additional favor to the longer lasting article.

Equivalent Yearly Burden. Returning to the one-year article it will be noted that when inflation is a factor the annual cost is no longer constant but forms a series of increasing costs which were obtained from the following operations.

$$10{,}000(1.04)^0\ (1.08) = \$10{,}800$$
$$10{,}000(1.04)^1\ (1.08) = 11{,}232$$
$$10{,}000(1.04)^2\ (1.08) = 11{,}681$$

These can be written as:

$$10{,}800(1.04)^0 = \$10{,}800$$
$$10{,}800(1.04)^1 = 11{,}232$$
$$10{,}800(1.04)^2 = 11{,}681$$

which can be condensed to

$$k_4 = \$10{,}800 \rightarrow$$

where the arrow at the right emphasizes that the end-of-year annual cost $10,800 increases by the factor $(1 + d)$ each year.

The symbol k_d designates "equivalent uniform end-of-year yearly burden." It is not a uniform cost when inflation is a factor, but keeps in step with inflation by increasing by the factor $(1 + d)$ each year. Under such conditions it is a uniform burden. For brevity it will be called "equivalent yearly burden."

When inflation is present cost comparisons can be made on the basis of the equivalent yearly burden. It follows that the article or system having the lowest equivalent yearly burden is the most economical.

The equivalent yearly burden is a generalized concept that reduces to the ordinary uniform Annual Cost method when there is no inflation.

The Simplest Case. Suppose an article costs C dollars now, lasts m years, i and d are respectively the decimal interest and inflation rates, and k_d is the equivalent yearly burden. then

$$C(1+i)^m = k_d(1+d)^0(1+i)^{m-1} + k_d(1+d)^1(1+i)^{m-2} + \ldots + k_d(1+d)^{m-1}(1+i)^{m-m} \quad (1)$$

The left hand side of Equation (1) is the value of the initial cost C at compound interest for m years. The right hand side is the cumulative value of the equivalent yearly burden at the end of m years. The equation can be condensed to:

$$C(1+i)^m = k_d \sum_{x=1}^{x=m} (1+d)^{x-1}(1+i)^{m-x} \quad (2)$$

This can be rearranged to:

$$C = k_d \left(\frac{1}{1+d}\right)^m \sum_{x=1}^{x=m} \left(\frac{1+d}{1+i}\right)^x$$

and reduces to:

$$k_d = C(i-d)\frac{I_{m,\,i}}{I_{m,\,i} - I_{m,\,d}} \quad (3)$$

$$I_{m,\,i} = (1+i)^m$$

$$I_{m,\,d} = (1+d)^m$$

The I factor is simply the compound interest factor values of which are given in Table 1.

Example 1—An article costs $10,000 and lasts one year. How much can be spent for an article that lasts three years if money is worth 8 percent per year and the inflation rate is 4 percent per year?

The problem was evaluated earlier in the article, but here the solution is based on Equation *(3)*. For equal equivalent yearly burdens for the one- and 3-year articles:

$$10{,}000\,(0.08-0.04)\frac{I_{1,\,8\%}}{I_{1,\,8\%} - I_{1,\,4\%}} = C\,(0.08-0.04)\frac{I_{3,\,8\%}}{I_{3,\,8\%} - I_{3,\,4\%}}$$

$$10{,}000\,(0.04)\,\frac{1.80}{1.08-1.04} = C\,(0.04)\,\frac{1.2597}{1.2597-1.1249}$$

$$C = \$28{,}893.$$

This checks the earlier result.

Add Income Tax. When taxes are considered the relationships are best expressed in terms of r, the decimal rate of return *after* taxes. Also let t designate the decimal income tax rate, D_x the decimal depreciation for the x-th year, and C_d the depreciable first cost, which is the first cost minus salvage value. Income tax will be treated as paid in a single installment at the end of the year.

Suppose an expense C_d is incurred now. At the end of the first year there will be a depreciation allowance C_dD_1 which will reduce taxes by tC_dD_1 and this amount can be regarded as income. Similarly there will be an income tC_dD_2 at the end of the second year.

If an article has a depreciable first cost C_d, and lasts m years the following relationship must hold where $k_{t,d}$ designates equivalent yearly burden after taxes with inflation included:

$$C_d(1+r)^m - tC_d \sum_{x=1}^{x=m} D_x(1+r)^{m-x} = k_{t,\,d} \sum_{x=1}^{x=m} (1+d)^{x-1}(1+r)^{m-x} \quad (4)$$

Equation (4) is on an after tax basis and is similar to Equation (2). The left hand side is the cost of the depreciable first cost less the savings in taxes resulting from the depreciation allowance, all referred to a time m years from now. As before the right hand side is the cumulative value of the equivalent yearly burden at the end of m years.

TABLE 1

Value of $I_{m,\,i} = (1+i)^m$

m	$I_{m,4}$	$I_{m,6}$	$I_{m,8}$	$I_{m,10}$	$I_{m,12}$	$I_{m,15}$	$I_{m,20}$	$I_{m,25}$	$I_{m,30}$	$I_{m,40}$	$I_{m,50}$
1	1.040	1.060	1.080	1.100	1.120	1.150	1.200	1.250	1.300	1.400	1.500
2	1.082	1.124	1.166	1.210	1.254	1.323	1.440	1.563	1.690	1.960	2.250
3	1.125	1.191	1.260	1.331	1.405	1.521	1.728	1.953	2.197	2.744	3.375
4	1.170	1.263	1.361	1.464	1.574	1.749	2.074	2.441	2.856	3.842	5.063
5	1.217	1.338	1.469	1.611	1.762	2.011	2.488	3.052	3.713	5.378	7.594
6	1.265	1.419	1.587	1.772	1.974	2.313	2.986	3.815	4.827	7.530	11.39
7	1.316	1.504	1.714	1.949	2.211	2.660	3.583	4.768	6.275	10.54	17.09
8	1.387	1.594	1.851	2.144	2.476	3.059	4.300	5.961	8.157	14.76	25.63
9	1.423	1.690	1.999	2.358	2.773	3.518	5.160	7.451	10.61	20.66	38.44
10	1.480	1.791	2.159	2.594	3.106	4.046	6.192	9.313	13.79	28.93	57.67
15	1.801	2.397	3.172	4.177	5.474	8.137	15.41	28.42	51.19	155.6	437.9
20	2.191	3.207	4.661	6.728	9.646	16.37	38.34	86.74	190.1	836.7	3,325.
25	2.666	4.292	6.849	10.84	17.00	32.92	95.40	264.7	705.7	4,500.	25,250.

TABLE 2—Abbreviated Tabulation of Factors Used in Equations

m	$I_{m,\ 4\%}$	$I_{m,\ 8\%}$	$\psi_{m,\ 8\%}^{SD}$	$(1-0.52\ \psi_{m,\ 8\%}^{SD})$	$\left(\frac{I_{m,\ 8\%}}{I_{m,\ 8\%}-I_{m,\ 4\%}}\right)$
1	1.0400	1.0800	0.9259	0.5185	27.00
2	1.0816	1.1664	0.9035	0.5302	13.75
3	1.1249	1.2597	0.8817	0.5415	9.342
4	1.1699	1.3605	0.8598	0.5529	7.138
5	1.2167	1.4693	0.8397	0.5634	5.817
10	1.4802	2.1589	0.7477	0.6112	3.181

Equation (4) reduces to

$$k_{t,\ d} = C_d\ (1 - t\psi_{m,r})\ (r - d)\frac{I_{m,\ r}}{I_{m,\ r} - I_{m,\ d}} \qquad (5)$$

$$\text{where } \psi_{m,\ r} = \sum_{x=1}^{x=m} \frac{D_x}{(1+r)^x}$$

The Ψ factor is the present value of the decimal depreciation and can be calculated for any method of depreciation. Figure 1 is a plot of its value for sum-of-the-digits depreciation for various rate of returns and values of m up to 25 years. The superscript *SD* in the factor is used to specifically denote sum-of-the-digits depreciation. The equations are valid for any method of depreciation, but sum-of-the-digits depreciation is used in the numerical examples.

If the article has a salvage value this is incorporated in part in Equation (5) since C_d is the depreciable first cost, that is first cost minus salvage value. Salvage value will be considered further in Equation (10).

For convenience in checking the numerical examples of this article an abbreviated tabulation of factors is given in Table 2.

Example 2—A tank costs $10,000 and lasts two years. Money is worth 8 percent per year after taxes, the income tax rate is 52 percent, and the inflation rate is 4 percent per year. How much can be spent for a tank that lasts five years?

By Equation (5) the equivalent yearly burden for the two year tank is:

$$k_{t,\ d} = 10{,}000\ (1 - 0.52\ \psi_{2,\ 8\%})\ (0.08 - 0.04)\ \frac{I_{2,\ 8\%}}{I_{2,\ 8\%} - I_{2,\ 4\%}}$$
$$= (10{,}000)\ (0.5302)\ (0.04)\ (13.75)$$
$$= \$2{,}916.$$

For the five-year tank with the same equivalent yearly burden:

$$2{,}916 = C_d\ (1 - 0.52\ \psi_{5,\ 8\%})\ (0.08 - 0.04)\ \frac{I_{5,\ 8\%}}{I_{5,\ 8\%} - I_{5,\ 4\%}}$$
$$2{,}916 = C_d\ (0.5634)\ (0.04)\ (5.817)$$
$$C_d = \$22{,}240.$$

That is up to $22,240 can be spent for the five-year tank.

Example 3—Anodes cost $10,000 and last one year. Money is worth 8 percent per year after taxes, the income tax rate is 52 percent, and the inflation rate is 4 percent per year. How long would anodes that cost $35,000 have to last?

By Equation (5) the equivalent yearly burden for the one year anodes is

$$k_{t,\ d} = 10{,}000\ (1 - t\ \psi_{1,\ 8\%})\ (0.08 - 0.04)\ \frac{I_{1,\ 8\%}}{I_{1,\ 8\%} - I_{1,\ 4\%}}$$

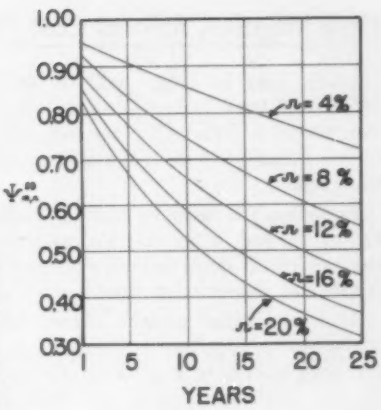


FIGURE 1 — Here's a plot of the present value of the decimal depreciation factor (ψ) for various rates of return (r) and values of (m) up to 25 years. SD denotes sum-of-the-digits depreciation.

$$= (10{,}000)\ (0.5185)\ (0.04)\ (27.00)$$
$$= \$5{,}600.$$

Equivalent yearly burden for the $35,000 anodes basis a three-year life is:

$$k_{t,d} = 35{,}000\ (1 - 0.52\ \psi_{3,\ 8\%})\ (0.08 - 0.04)\frac{I_{3,\ 8\%}}{I_{3,\ 8\%} - I_{3,\ 4\%}}$$
$$= 35{,}000\ (0.5415)\ (0.04)\ (9.342)$$
$$= \$7{,}082.$$

The $35,000 anodes will have to last over 3 years. Their equivalent uniform yearly burden basis a 4 year life is:

$$k_{t,\ d} = 35{,}000(1 - 0.52\ \psi_{4,\ 8\%})\ (0.08 - 0.04)\ \frac{I_{4,\ 8\%}}{I_{4,\ 8\%} - I_{4,\ 4\%}}$$
$$= (35{,}000)\ (0.5529)\ (0.04)\ (7.138)$$
$$= \$5{,}525.$$

The $35,000 anodes would not have to last four years. By interpolation they would have to last about 3.9 years to have an equivalent yearly burden of $5,600.

Uniform Annual Expense. If *M* is a uniform annual expense—uniform except for the effect of inflation—the equivalent yearly burden is obtained by placing $m = 1$ in Equation (5):

$$k_{t,d} = M(1 - t\ \psi_{1,r})\ (1 + r) \qquad (6)$$

$$\psi_{1,r} = \frac{1}{1+r}$$

M is an expense which occurs as a single expense as of the *beginning* of the year. Numerically *M* is the first year expense. This expense will increase by a factor $(1 + d)$ each year, but this is allowed for in the equation. Also, Equation (6) assumes that *M* will be written off in full at the end of the year for tax purposes.

The Annual Cost method as generally used regards a yearly expense as occurring at the *end* of the year.

If *M'* in terms of today's dollar is a uniform annual expense—uniform except for the effect of inflation—and *M'* refers to the end of the year, the equivalent yearly burden is:

$$k_{t,d} = M'\ (1 + d)\ (1 - t). \qquad (7)$$

M' is actually a single expense occurring at the end of the year but in terms of today's dollar and prices. When the first expense comes due at the end of the first

year the cost in dollars will be M' (1 + d) because prices will have increased from inflation, but the equation allows for this. Also, the cost each year will increase by the factor (1 + d) but this is allowed for in the equation also.

Equation (7) assumes that M' will be written off in full at the end of the year for tax purposes. Both M' and the tax credit occur at the end of the year, so the expense and depreciation credit occur simultaneously.

It is true that certain annual expenses, such as a maintenance expense, would probably occur throughout the year wheras in Equations (6) and (7) both M and M' are single expenses at the beginning and end of the year respectively. Unless continuously compounded interest and inflation are used any expense must be treated by its equivalent at the beginning of the year, or the end of the year, inasmuch as a year is the smallest time interval considered in this presentation.

For Equations (6) and (7) to be equal

$$M' = \frac{M}{(1+d)}\left(1+\frac{r}{1-t}\right).$$

Example 4—A tank costs $10,000 and lasts two year. Money is worth 8 percent per year after taxes, the income tax rate is 52 percent, and the inflation rate is 4 percent per year. How much can be spent for lining the tank at the beginning of each year so as to get a five-year life?

Equivalent yearly burden of the two-year tank was calculated in Example 2 and is $2,916.

Equivalent yearly burden of the lined tank must not exceed $2,916 and is obtained by combining Equations (5) and (6).

$$2{,}916 = (10{,}000)\ (1 - 0.52\,\psi_{s,8\%})\ (r-d)\frac{I_{s,8\%}}{I_{s,8\%} - I_{s,4\%}} + M(1 - 0.52\,\psi_{s,8\%})\ (1+r)$$

$$2{,}916 = (10{,}000)\ (0.5634)\ (0.08 - 0.04)\ (5.817) + M(0.5185)\ (1.08)$$

$$M = \$2{,}866.$$

Up to $2,866 can be spent at the beginning of the first year with the understanding that the cost will rise 4 percent per year for each of the remaining four years.

Irregular Yearly Expense. Equations (6) and (7) are only suitable if the yearly expense is uniform, except for the effect of inflation, and occurs every year. When the yearly expense is irregular more general equations are needed.

Suppose an expense B_x, in the terms of the present dollar, is incurred at the beginning of the x-th year for an article lasting m years. Moreover B_x is written off in full at the end of the x-th year. Then the equivalent yearly burden of the single expense B_x is:

$$k_{t,d} = B_x\ (1 - t\,\psi_{s,r})\ (I_{(x-1),d})\ (r-d)\frac{I_{(m-x+1),r}}{I_{m,r} - I_{m,d}} \qquad (8)$$

As mentioned B_x is in terms of the present dollar. The equation allows for the fact that the expense will actually be $B_x(1 + d)^{x-1}$ when it is incurred at the beginning of the x-th year.

If an expense B'_x, in terms of the present dollar, is incurred at the *end* of the x-th year for an article lasting m years and the expense can be written off in full at the end of the x-th year, the equivalent yearly burden of the single expense B'_x is:

$$k_{t,d} = B'_x\ (1-t)\ (I_{x,d})\ (r-d)\frac{I_{(m-x),r}}{I_{m,r} - I_{m,d}} \qquad (9)$$

Again B'_x is in terms of the present dollar and the equation allows for an actual cost of $B'_x(1 + d)^x$ when the cost is incurred at the end of the x-th year.

Equations (8) and (9) can be summed for all the years permitting yearly expenses, and receipts, to be accommodated regardless of how irregular they may be.

For Equations (8) and (9) to be equal:

$$B'_x = \frac{B_x}{(1+d)}\left(1+\frac{r}{1-t}\right)$$

Salvage Value. It was mentioned that in Equation (5) C_d is the depreciable part of the first cost and is equal to the first cost less the salvage value. Here we consider the nondepreciable part of the first cost, the salvage value L.

If an article lasts m years and has a salvage value L, in terms of today's dollar, equivalent yearly burden of the salvage value is

$$k_{t,d} = +L\ (r-d)\left(1 + g\frac{I_{m,d} - 1}{I_{m,r} - I_{m,d}}\right) \qquad (10)$$

where g is the capital gains tax expressed as a decimal. The positive sign before L in Equation (10) is correct.

Equation (10) is complicated because due to inflation the salvage value will be greater than anticipated based on present prices. On disposal the salvage value will show a profit subject to taxes in some way that may vary with the circumstances and the company. In Equation (10) the profit is subjected to the capital gains tax g that is now 25 percent for corporations.

Nondepreciable Expenses. Let N denote the present purchase price of a nondepreciable expense, such as the land on which a plant is built, for a venture lasting m years. Assume further that at the end of m years the land will not be sold but will be used for another venture. For this case Equation (10) will apply with $g = 0$ and the equivalent yearly burden will be:

$$k_{t,d} = N\ (r-d) \qquad (11)$$

Working Capital. Working capital is used for more than one purpose, but the discussion here is limited to working capital that can be regarded as cash on hand to conduct a venture.

If C_w represents a cash sum put up now to conduct a venture lasting m years the equivalent yearly burden is:

$$k_{t,d} = C_w\ (r) \qquad (12)$$

Equation (12) assumes that the working capital will have to keep in step with inflation. The working capital will be C_w for the first year, $C_w(1 + d)$ for the second year, $C_w(1 + d)^2$ for the third year and so forth. At the end of m years $C_w(1 + d)^{m-1}$ dollars will be recovered in cash.

An Extensive Example. The following example shows how various different types of costs are treated in one problem.

Example 5—A heat exchanger uses steel tubes which cost $10,000 and last four years with $2,000 salvage value. Cost for cleaning the inside of the tubes is $3,000 per year referred to the beginning of the year.

At the beginning of the third year the outside of the tubes must be cleaned at a cost of $4,000, and at the beginning of the fourth year there is an extra maintenance expense of $1,500.

It is proposed to substitute alloyed tubes costing $95,000 which last 10 years with $20,000 salvage value. Maintenance for the alloyed tubes is $1,000 per year and savings from increased production $6,000 per year, or net of —$5,000 per year referred to the beginning of the year.

All the above costs are in terms of today's dollar. Money is worth 8 percent per year after taxes, the inflation rate is 4 percent per year, the income tax is 52 percent, and the capital gains tax is 25 percent. Does it pay to install the alloy tubes?

Equivalent yearly burden of the steel tubes by Equations (5), (10), (6), and (8) twice, in order is:

$$(10{,}000 - 2{,}000)\ (1 - 0.52\ \psi_{4,8\%})$$

$$\times\ (0.08 - 0.04)\ \frac{I_{4,8\%}}{I_{4,8\%} - I_{4,4\%}} =$$

$$(8{,}000)\ (0.5529)\ (0.04)\ (7.138) \qquad = \$1{,}263$$

$$(2{,}000)\ (0.08 - 0.04)\left(1 + 0.25\frac{I_{4,4\%} - 1}{I_{4,8\%} - I_{4,4\%}}\right)$$

$$= (2{,}000)\ (0.04)\ (1.2229) \qquad = \quad 98$$

$$(3{,}000)\ (1 - 0.52\ \psi_{1,r})\ (1.08) =$$

$$(3{,}000)\ (0.5185)\ (1.08) \qquad = 1{,}680$$

$$(4{,}000)\ (1 - 0.52\ \psi_{2,r})\ (I_{2,6\%}) \times$$

$$(0.08 - 0.04)\frac{I_{2,6\%}}{I_{4,8\%} - I_{4,4\%}}$$

$$= (4{,}000)\ (0.5185)\ (1.0816)\ (0.04)\ (6.119) = \quad 549$$

$$(1{,}500)\ (1 - 0.52\ \psi_{1,r})\ (I_{2,6\%}) \times$$

$$(0.08 - 0.04)\frac{I_{1,8\%}}{I_{4,8\%} - I_{4,4\%}}$$

$$= (1{,}500)\ (0.5185)\ (1.1249)\ (0.04)\ (5.666) = \underline{198}$$

$$k_{t,d} = \$3{,}788$$

Equivalent yearly burden of the alloy tubes by Equations (5), (10), and (6), in order is:

$$(95{,}000 - 20{,}000)\ (1 - 0.52\ \psi_{10,8\%}) \times (0.08 - 0.04)$$

$$\frac{I_{10,8\%}}{I_{10,8\%} - I_{20,4\%}}$$

$$= (75{,}000)\ (0.6112)\ (0.04)\ (3.181) \qquad = \$5{,}833$$

$$(20{,}000)\ (0.08 - 0.04)\left(1 + 0.25\ \frac{I_{10,4\%} - 1}{I_{20,8\%} - I_{4,4\%}}\right)$$

$$= (20{,}000)\ (0.04)\ (1.1769) \qquad = \quad 942$$

$$-\ (5{,}000)\ (1 - 0.52\ \psi_{1,r})\ (1.08)$$

$$= -\ (5{,}000)\ (0.5185\ (1.08) \qquad = -\ \underline{2{,}800}$$

$$k_{t,d} = \$3{,}975$$

It does not pay to install the alloy tubes with an equivalent yearly burden of $3,975 against $3,788 for the steel tubes.

Omission of Some Rates. Equations (5) through (12) cover virtually all types of costs which occur in practical problems and are extensive as they allow for all three rates: rate of return, taxes, and inflation. If any of these rates is to be ignored, write the equations with the particular rate equal to zero. For example Equation (5) with inflation ignored becomes:

$$k_t = C_d\ (1 - t\ \psi_{m,r})\ (r)\ \frac{I_{m,r}}{I_{m,r} - 1}$$

With taxes only ignored it would be written:

$$k_d = (C - L)\ (i - d)\frac{I_{m,i}}{I_{m,i} - I_{m,d}}$$

With both taxes and inflation ignored it becomes:

$$k = (C - L)\ (i)\frac{I_{m,i}}{I_{m,i} - 1}$$

High Inflation Rates. Equations (5) through (12) are valid as written whether the inflation rate is lower or higher than the rate of return. However, when $d > r$ some of the relationships can be expressed in a more convenient form. For example when $d > r$ Equation (5) contains the terms $(r - d)$ and $(I_{m,r} - I_{m,d})$ both of which become negative although Equation (5) itself remains positive. For this circumstance Equation (5) is written more conveniently as:

$$k_{t,d} = C_d\ (1 - t\ \psi_{m,r})\ (d - r)\frac{I_{m,r}}{I_{m,d} - I_{m,r}}$$

and the same applies to Equations (8) and (9). Note that when $d > r$ Equation (11) becomes negative, and Equation (10) can become negative.

Equal Inflation and Return Rates. For the special case of equal rates, that is $d = r$, several of the preceeding equations take the form 0/0 and must be futher evaluated by the calculus. The relationships corresponding to Equations (5) through (12) are respectively:

$$k_{t,d=r} = \frac{C_d}{m}(1 - t\ \psi_{m,r})\ (1 + r) \qquad (13)$$

$$k_{t,d=r} = M\ (1 - t\ \psi_{i,r})\ (1 + r) \qquad (14)$$

$$k_{t,d=r} = M'\ (1 - t)\ (1 + r) \qquad (15)$$

$$k_{t,d=r} = \frac{B_x}{m}\ (1 - t\ \psi_{i,r})\ (1 + r) \qquad (16)$$

$$k_{t,d=r} = \frac{B'_x}{m}\ (1 - t)\ (1 + r) \qquad (17)$$

$$k_{t,d=r} = L\left(\frac{g}{m}\right)\ \left(\frac{I_{m,r} - 1}{I_{m,r}}\right)(1 + r) \qquad (18)$$

$$k_{t,d=r} = N(O) = 0 \qquad (19)$$

$$k_{t,d=r} = C_w\ (r) \qquad (20)$$

Example 6—An article costs $10,000 and lasts one year. How much can be spent for an article that lasts 10 years if both the return on investment after taxes and the inflation rates are 8 percent per year and the income tax is 52 percent?

Equivalent yearly burden for the one year article by Equation (13) is:

$$k_{t,d=r} = \frac{10{,}000}{1}(1 - 0.52\ \psi_{2,8\%})\ (1.08)$$

$$= (10{,}000)\ (0.5185)\ (1.08)$$

$$= \$5{,}600.$$

Using the same equivalent yearly burden for the 10 year article:

$$5{,}600 = \frac{C_d}{10}(1 - 0.52\ \psi_{20,8\%})\ (1.08)$$

$$= \frac{C_d}{10}(0.6112)\ (1.08)$$

$$C_d = \$84{,}840$$

Fast Write-Off. If a facility lasting m years is permitted to be written off in less than m years for tax purposes, only the ψ factor need be changed. For the ψ factor substitute for m the number of years in which the facility will be written off. For other factors leave m unchanged.

Capitalized Cost.[3] The earlier reference[2] which included all three rates—rate of return, income tax, and inflation—was based on capitalized cost. A simple numerical example will show that a comparison will be the same whether based on equivalent yearly burden or capitalized cost.

When the rate of return after taxes is greater than the inflation rate the relationships for capitalized cost are obtained by dividing Equations (5) through (12) by (r — d). For example Equation (5) then becomes

$$K_{t,d} = C_d\ (1 - t\,\psi_{m,r})\ \frac{I_{m,r}}{I_{m,r} - I_{m,d}} \qquad r > d \qquad (21)$$

Example 7—Rework Example 2 on the basis of capitalized cost.

By Equation (21) the capitalized cost of the 2 year tank is:

$$K_{t,d} = 10{,}000\ (1 - 0.52\ \psi_{2,8\%})\ \frac{I_{2,8\%}}{I_{2,8\%} - I_{2,6\%}}$$

$$= (10{,}000)\ (0.5302)\ (13.75)$$

$$= \$72{,}900$$

For the 5 year tank with the same capitalized cost:

$$72{,}900 = C_d\ (1 - 0.52\ \psi_{5,6\%})\ \frac{I_{5,6\%}}{I_{5,8\%} - I_{5,4\%}}$$

$$72{,}900 = C_d\ (0.5634)\ (5.817)$$

$$C_d = \$22{,}240$$

This checks the earlier result obtained on the basis of equivalent yearly burden.

High Inflation Rates. When the inflation rate is higher than the rate of return after taxes the calculation can be made on the basis of extended capitalized cost. The relationships are obtained by dividing Equations (5) through (12) by (d — r). For example Equation (5) would then become

$$K_{t,d>r} = C_d\ (1 - t\,\psi_{m,r})\ \frac{I_{m,r}}{I_{m,d} - I_{m,r}} \qquad d > r \qquad (22)$$

Equal Rates. When the inflation rate and the rate of return after taxes are equal the capitalized cost method is indeterminate and for this circumstance the solution must be based on equivalent yearly burden using Equations (13) through (20).

Entire Venture. By combining suitable equations the equivalent yearly burden can be applied to an entire venture to determine if the receipts over a period of years justify the venture. Thus from Equations (5), (9), (10), (11), and (12):

$$k_{t,d} = C_d\ (1 - t\,\psi_{m,r})\ (r - d)\ \frac{I_{m,r}}{I_{m,r} - I_{m,d}}$$

$$+ (1 - t)\ (r - d)\ \frac{I_{m,r}}{I_{m,r} - I_{m,d}} \sum_{x=1}^{x=m} B'_x\ \frac{I_{x,d}}{I_{x,r}}$$

$$+ L\ (r - d)\left(1 + g\ \frac{I_{m,d} - 1}{I_{m,r} - I_{m,d}}\right)$$

$$+ N\ (r - d) + C_w\ (r)$$

Here C_d is the depreciable initial cost of the facility lasting m years. B'_x is the net yearly expense in terms of today's dollar, before taxes and depreciation, referred to the end of the x-th year. B'_x for the most years must be negative, a net income, if the project is to pay off. L is salvage value in terms of today's dollar. N represents the cost for a non-depreciable first cost such as land. C_w is working capital with the understanding that it will have to be increased by the factor (1 + d) each year to keep in step with inflation.

If $k_{t,d}$ is negative the venture pays off at a rate better than r. If $k_{t,d}$ is positive the venture will not pay off at the rate r but is not necessarily a loser as it may pay off at some lower rate of return. If the equation is solved for that value of r which makes $k_{t,d}$ zero, then r is the rate of return for the venture.

LITERATURE CITED

[1] Grant, Eugene L., Principles of Engineering Economy, Ronald Press, N. Y., 3rd Ed. 1950.
[2] Jelen, F. C., *Chem. Eng.*, Jan. 27, 1958, 123-128.
[3] Jelen, F. C., Petroleum Refiner, Jan. 1958, 195-201.

NOMENCLATURE

B_x	Expense, beginning of x-th year, present dollars.
B'_x	Expense, end of x-th year, present dollars.
C	Initial cost of a facility, dollars.
C_d	Initial depreciable cost of a facility, dollars.
C_w	Working capital, dollars.
d	Inflation rate, decimal per year.
D_x	Depreciation for x-th year, decimal.
g	Capital gains tax, decimal.
i	Rate of return before taxes, decimal per year.
$I_{m,r}$	$(1+r)^m$, compound interest factor.
k	Equivalent annual cost, dollars per year.
k_d	Equivalent yearly burden, dollars per year.
k_t	Equivalent annual cost after taxes, dollars per year.
$k_{t,d}$	Equivalent yearly burden after taxes, dollars per year.
$k_{t,d=r}$	Equivalent yearly burden after taxes for d = r, dollars per year.
$K_{t,d}$	Capitalized cost after taxes and with inflation for r > d, dollars.
$K_{t,d>r}$	Extended capitalized cost after taxes and with inflation for d > r, dollars.
L	Salvage value, present dollars.
m	Life of a facility, years.
M	Uniform beginning-of-year expense, present dollars per year.
M′	Uniform end-of-year expense, present dollars per year.
N	Non-depreciable expense, dollars.
r	Rate of return after taxes, decimal per year.
SD	Sum-of-the-digits method of depreciation.
t	Income tax rate, decimal.
x	The x-th year.
$\psi_{m,r}$	A factor associated with depreciation.

About the Author

F. C. Jelen, corrosion engineer in charge of corrosion control at Solvay Process division, Allied Chemical Corp., is a licensed professional engineer in New York and has had over 20 years experience in heavy chemical industries. He received his B.S. and M.S. degrees from M.I.T. and a Ph.D. degree from Harvard University graduate school of Arts and Sciences. Jelens paper on "Cost Comparisons by Capitalized Cost" appeared in the January, 1958 Petroleum Refiner.

Can You Justify a CO Boiler?

All the important variables have been correlated and plotted to help you answer this question.

W. H. Alexander and R. L. Bradley
The Stearns-Roger Manufacturing Co., Denver

OBTAINING MAXIMUM fuel economy by recovery of heat from catalytic cracking unit regenerator flue gas is a continuing effort. The regenerator flue gas usually represents a large quantity of high temperature gas. It also contains varying amounts of combustibles and is available for discharge from the unit at a positive pressure. The flue gas stream therefore represents an ideal potential source of fuel economy. The processes for doing this are numerous.

However, there are generally one or two processes which prove to be least troublesome, most economical or least costly. Among the means of recovering heat from catalytic cracking unit flue gas streams, CO boilers usually fall into these categories.

Advantages. A CO boiler may provide several advantages to a refiner. First is the production of refinery steam. Heat is available from carbon monoxide combustion and from the sensible heat of the regenerator flue gas. This is the usual reason for installing a CO boiler.

Second, the CO boiler can eliminate or materially reduce the quantity of air pollutants discharged to the atmosphere.

CO boilers need not be confined to catalytic cracking units, although this is the usual adaptation. The flue gas from a fluid coking unit may be even more attractive as a source of CO gas. However, considered here is the use of a CO boiler in conjunction with a catalytic cracking unit. Further, its justification is based solely on the

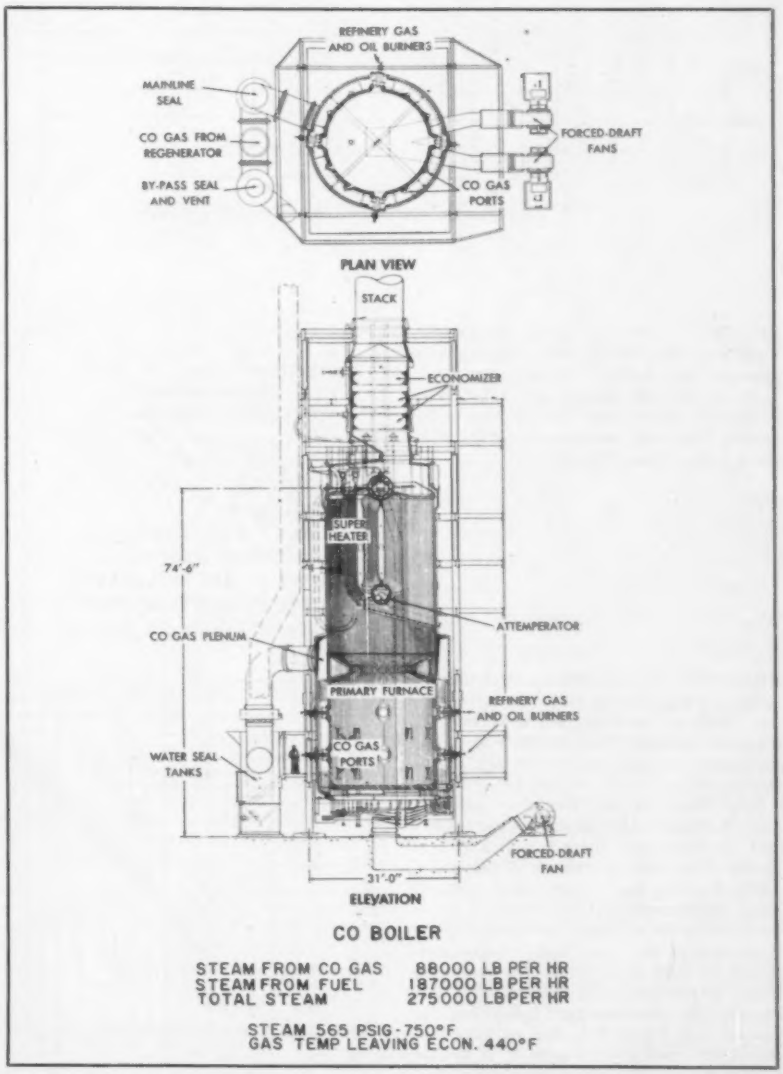


FIGURE 1—This cross-section of a typical CO boiler shows how the CO and fuel gas is fired tangentially and also how the CO can be bypassed when the boiler is down for inspection.

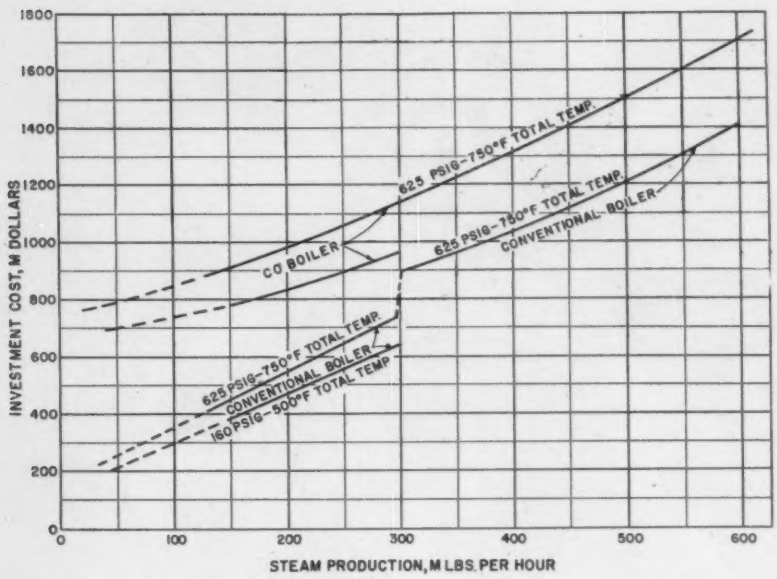


FIGURE 2 (Above)—Here's how investment costs for CO boilers compare with conventional boilers. Notice the break point at 300,000 pounds per hour. This is because above that size all boilers are custom built and are invariably for pressures higher than 160 psig.

economic incentive derived from the improvement in the overall thermal efficiency of the refinery.

Usually a CO boiler in a specific refinery is to improve the refinery's overall energy balance. This assumes that refinery fuel is not or would not be flared or otherwise deliberately wasted. A CO boiler does not always improve refinery economics even when helping the energy balance. There are minimum capacities, flue gas temperatures, fuel values, etc., which determine the economic desirability of a CO boiler for a specific refinery. Generalized correlations are presented here to help define these limits. From these a refiner can quickly determine the possible economy of a CO boiler in his refinery.

Today CO boilers are fairly standardized as to size for gas flow and steam production.[1] However, special

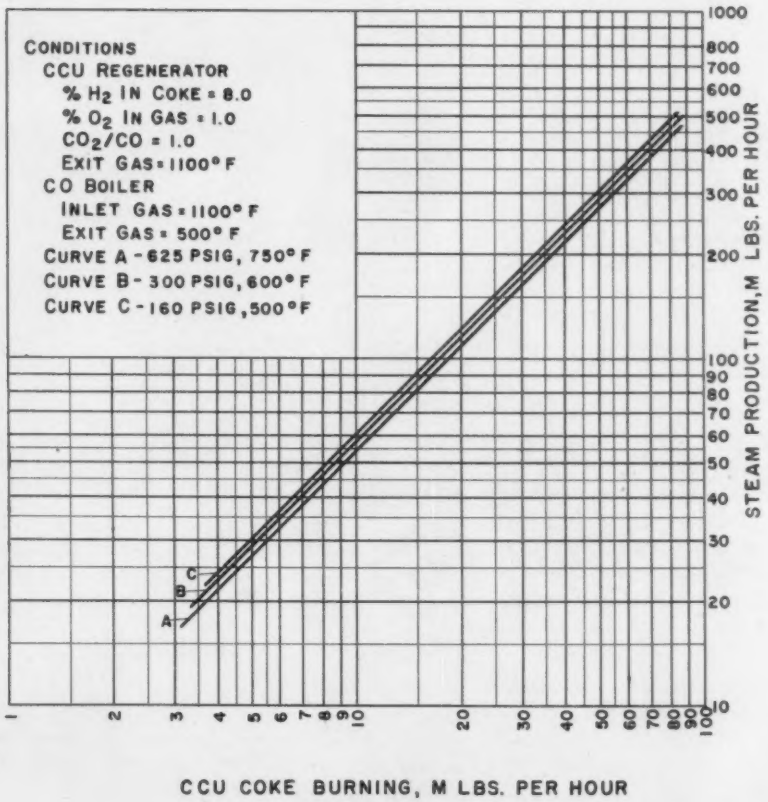

CONDITIONS
CCU REGENERATOR
% H_2 IN COKE = 8.0
% O_2 IN GAS = 1.0
CO_2/CO = 1.0
EXIT GAS = 1100° F
CO BOILER
INLET GAS = 1100° F
EXIT GAS = 500° F
CURVE A - 625 PSIG, 750° F
CURVE B - 300 PSIG, 600° F
CURVE C - 160 PSIG, 500° F
A
B
C
STEAM PRODUCTION, M LBS. PER HOUR
CCU COKE BURNING, M LBS. PER HOUR

FIGURE 3 (Right)—Here's the minimum steam production you can expect for various catalytic cracking unit coke burning rates not counting supplementary fuel. The total steam production is from: (1) Combusion of the CO in the flue gas, (2) The sensible heat in the incoming flue gas, and (3) Combustion of any supplementary fuel. In some cases there is sufficient heat in the CO gases to provide a calculated 1900 F. fire box temperature without using supplementary fuel. However, to assure continuity of operation approximately 5 percent of the total heat requirements should be fired at all times. The minimum steam production shown above does not include this supplementary firing. For the general case Figure 3 is used to determine the boiler costs from Figure 2. A similar approach was used for all calculations, but these data are not presented directly as minimum steam production figures.

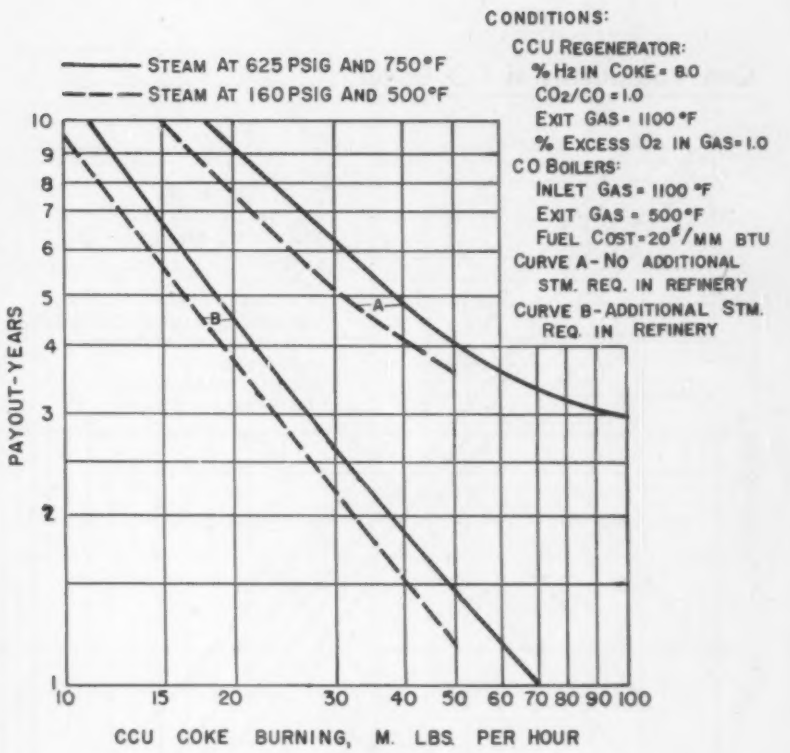
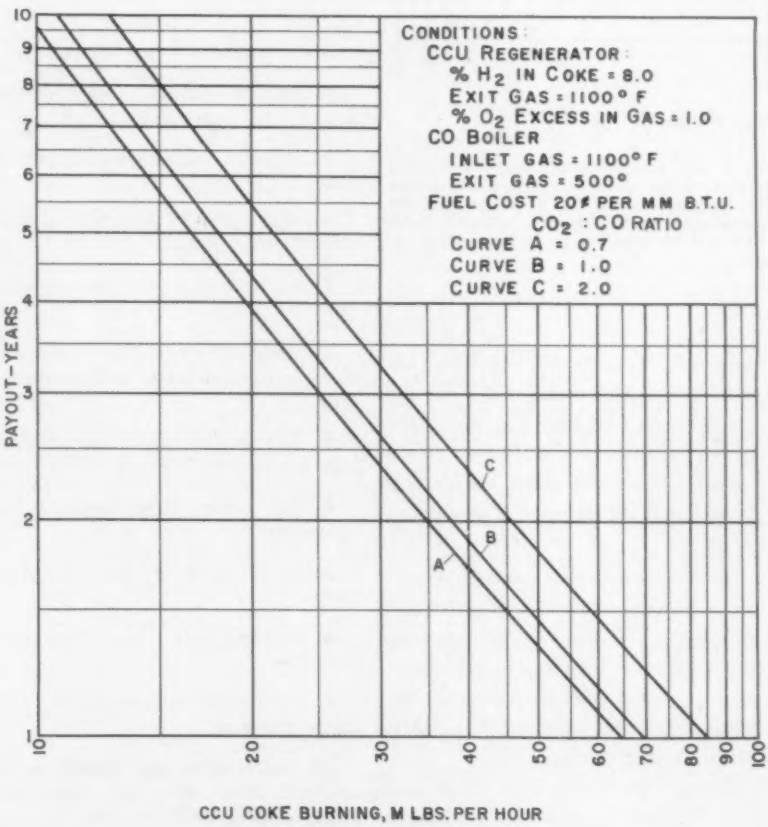

CONDITIONS:
CCU REGENERATOR:
% H2 IN COKE = 8.0
CO2/CO = 1.0
EXIT GAS = 1100 °F
% EXCESS O2 IN GAS = 1.0
CO BOILERS:
INLET GAS = 1100 °F
EXIT GAS = 500 °F
FUEL COST = 20¢/MM BTU
CURVE A - NO ADDITIONAL STM. REQ. IN REFINERY
CURVE B - ADDITIONAL STM. REQ. IN REFINERY
STEAM AT 625 PSIG AND 750 °F
STEAM AT 160 PSIG AND 500 °F
PAYOUT-YEARS
CCU COKE BURNING, M. LBS. PER HOUR

FIGURE 4(right)—Notice how the coke burning rate, less supplementary fuel, effects CO boiler payout. "A" curves are used to determine payout where additional steam is not required in the refinery. "B" curves are used when additional steam is needed and are based on the difference in costs determined from Figure 2.

FIGURE 5(below)—CO boiler payout is only moderately affected by CO_2/CO ratio in the catalytic cracking unit flue gas. The lower the ratio the more carbon monoxide is available for combustion. This results in a decreased payout for a low CO_2/CO ratio.


CONDITIONS:
CCU REGENERATOR:
% H2 IN COKE = 8.0
EXIT GAS = 1100 °F
% O2 EXCESS IN GAS = 1.0
CO BOILER
INLET GAS = 1100 °F
EXIT GAS = 500 °
FUEL COST 20¢ PER MM B.T.U.
CO2 : CO RATIO
CURVE A = 0.7
CURVE B = 1.0
CURVE C = 2.0
PAYOUT-YEARS
CCU COKE BURNING, M LBS. PER HOUR

needs may require custom design for a specific duty.[2] Generally, the CO boiler considered in these economic studies is similar to the unit shown in Figure 1. This is a vertical circular type boiler with water cooled or refractory furnace. Both CO gas and supplementary fuel are fired tangentially into a firebox maintained at 1800 F. minimum. The spent gases pass through vortex at the top of the furnace and then over superheater sections. The gases then cross the convection pass of the boiler, pass through an economizer and up the stack to the atmosphere. The CO gas can either be fired into the boiler unit or bypassed to the stack.

The boiler can operate on 100 percent supplementary fuel when the source of CO gas is cut off. The unit normally includes sootblowers, platforms, steel structures, instruments and controls and other items usually called trim. The boiler itself, however, does not contain an oxidation

Can You Justify a CO Boiler?

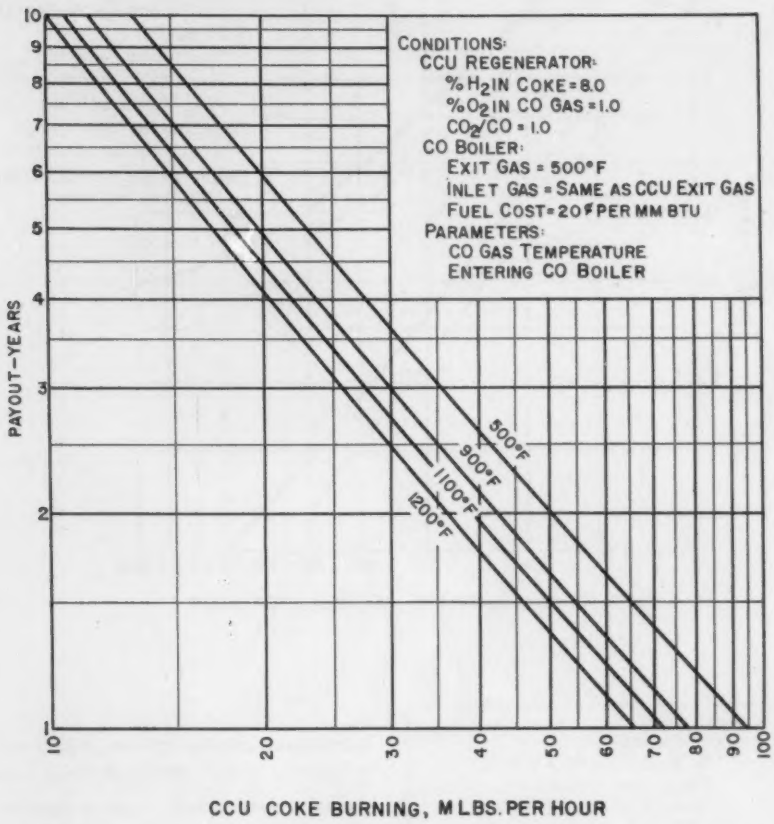


FIGURE 6—Notice that CO boiler payout is not materially affected by normal variations in outlet temperature of the regenerator. A major effect on payout is shown where a waste heat boiler on the flue gas cools the gas to about 500 F. at the required coke burning rate. Under these conditions virtually no sensible heat is available from the CO gas. Also additional supplementary fuel will be required to maintain 1800 F. combustion zone temperature in the CO boiler.

catalyst chamber for conversion of the carbon monoxide to carbon dioxide. It depends instead upon maintenance of a minimum 1800 F. CO gas combustion temperature within the primary furnace section by the introduction of supplementary fuel. Some supplementary fuel is always used to provide a source of ignition.

The refinery requirement for steam production is of paramount importance in evaluating a CO boiler. The poorest situation for justifying a CO boiler is when the refinery has adequate steam generation facilities and the CO boiler would retire existing operating equipment. The most advantageous economic situation for justifying a CO boiler is when the refinery is in need of additional steam capacity. The CO boiler could then be installed instead of a conventional boiler.

The accompanying curves present, for a general case, the incentive for installing a CO boiler in both extreme situations. All subsequent variations of the general case are based on the assumption that additional refinery steam capacity is required.

Figure 2 shows the differential cost of a CO boiler over a conventional boiler assuming additional steam generation facilities must be installed.

Catalytic cracking unit coke burning capacity is fundamental in determining the quantity and character of the regenerator flue gas. This number is readily available in the refinery. Therefore, the correlations presented, consider catalytic cracking unit coke burning rate as the primary independent variable.

Several simplifying assumptions have been necessary. Two of these are of interest at this point. One is that the regenerator-reactor heat balance does not affect the CO boiler evaluation. The second assumption is that any one physical condition of the regenerator could be varied without affecting other conditions.

Other variables affecting the CO boiler payout which have been investigated are:

1. CO_2/CO ratio

2. CO gas inlet temperature to the CO boiler

3. fuel value

4. volume percent excess oxygen in the regenerator flue gas

5. weight percent hydrogen in coke.

Normal variables which have been fixed in this study are:

1. quench water to the regenerator

2. stripping steam carryover and other sources of steam to the regenerator

3. CO boiler stack temperature and excess air

4. CO boiler supplementary fuel character

5. steam pressure and temperatures

6. ambient air temperature and humidity

7. continuous operating for 8,000 hours per year.

All correlations are based on an assumed total source of extraneous steam and water to the cat cracker

regenerator of 0.54 pounds per pound of coke burned. The CO boiler stack temperature has been fixed at 500 F. with 2 percent excess oxygen in the flue gas; the CO boiler supplementary fuel was assumed to be methane; and the CO boiler was assumed to receive feedwater at 240 F. Ambient air temperature was assumed at 80 F. and 50 percent relative humidity.

In order to simplify the correlations relating payout of CO boilers to coke burning capacity, a general case is presented in which the variables are fixed at assumed normal conditions. The effect of each variable is explored independently in subsequent correlations, while all other variables are held constant.

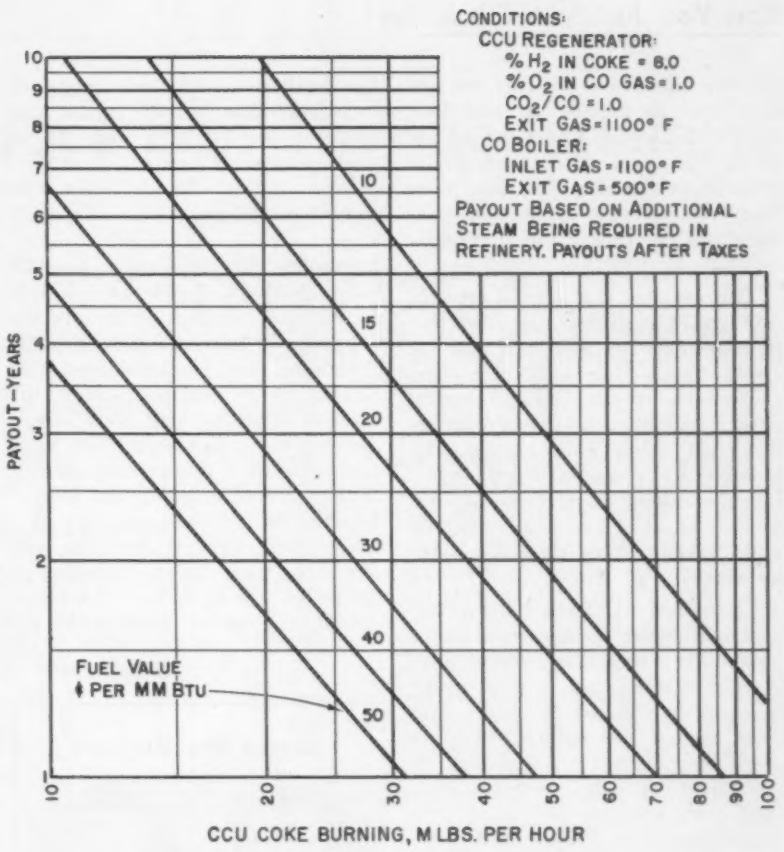
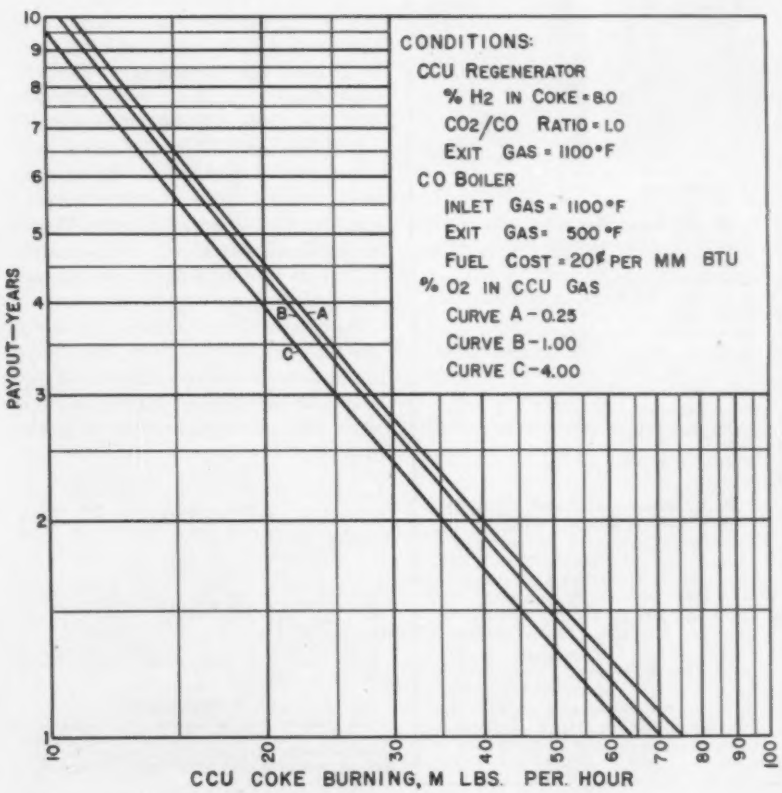


FIGURE 7 (right)—Fuel cost can greatly affect CO boiler payout. The general case is based on additional fuel (methane) costing 20 cents per million Btu. The payout after taxes shown are based on additional steam being required in the refinery. The general conditions used in other figures are also used for this set of curves. Payouts are nearly inversely proportional to fuel value at the constant coke burning rate.



For the general case operating variables have been fixed as follows:

1. Hydrogen in coke at 8.00 weight percent

2. excess oxygen in regenerator flue gas at 1.00 volume percent

3. CO_2/CO ratio at 1.00

4. CO gas inlet temperature to the CO boiler at 1100 F.

5. A fuel value of 20 cents per million Btu normally consumed in conventional boilers at 85 percent efficiency

6. Steam produced at 625 psig and 750 F.

Payout periods shown in Figures

FIGURE 8(left)—The effect of percent oxygen in the regenerator gas on CO boiler payout is minor.

4-8 are calculated for the assumed conditions as follows: A total heat absorption in the CO boiler is calculated. The total heat absorption is reduced to the net heat absorption from the CO gas stream by subtracting 85 percent of the supplementary fuel heat release.

This assumes that the 85 percent represents the efficiency of utilization of supplementary fuel in a conventional boiler. The heat absorption attributable to the CO gas stream is then multiplied by the supplementary fuel value in a conventional boiler at 85 percent efficiency to obtain the annual value of the CO gas as fuel. This CO gas value represents gross savings from the CO boiler installation.

The cost of a CO boiler and a conventional boiler at minimum steam production is determined from Figure 2 and the differential cost of a CO boiler determined by difference. The gross savings are reduced to gross profit by subtracting 12 percent of investment for annual maintenance, fixed costs and cost of capital. Annual depreciation was assumed to be 7 percent of investment. Net profit was computed after corporate taxes on the net taxable income after depreciation. The gross income that was applied to pay out the boiler cost was then the sum of depreciation and net profit after taxes. No charge has been applied against the CO boilers for operating labor. The assumption has been made that in the event of either conventional or CO boiler installation the manpower requirements would be the same. Also, the assumption has been made that a fuel saving will not force flaring of butane or refinery fuel. A payout of six years after taxes is assumed to be an attractive investment.

The effect of variable hydrogen content of the coke was investigated and found to be insignificant. This lack of variation is explained as follows: As the weight percent hydrogen content of the coke is increased at constant coke burning rate and at constant CO_2/CO ratio, the CO production decreases. But at the same time the total mass of regenerator flue gas increases by large proportions since one pound of hydrogen requires roughly six times the weight of air for combustion that one pound of carbon requires to form carbon monoxide. The resulting increase in available sensible heat at a fixed temperature offsets the decreased CO heat of combustion.

Summary. The economics of a CO boiler installation in conjunction with a catalytic cracking unit are specific for a given refinery. However, the economics may be generalized sufficiently to determine a range of catalytic cracking unit sizes which can pay out a CO boiler. The basic variable used in determining the size of the catalytic cracking unit is coke burning. Many other operating variables of the catalytic cracking unit affect the incentive for installing a CO boiler. The variables which affect payout other than catalytic cracking unit capacity are presented in order of decreasing importance as follows:

1. Fuel value
2. CO_2/CO ratio
3. Flue gas temperature
4. Excess oxygen in CO gas
5. Hydrogen content of regenerator coke.

The accompanying figures present generalized payout curves for CO boilers as a function of a cat cracker's coke burning rate. Assuming additional steam is required in the refinery, a coke burning rate of 10,000 pounds per hour or more can be attractive for installation of a CO boiler when the fuel has a value of 20 cents per million Btu. If additional steam is not required, the minimum coke burning rate to provide a reasonable payout for a CO boiler is about 18,000 pounds per hour. If the coke burning rate is much below this range there is little economic incentive to investigate a CO boiler unless the refiner desires to minimize the auxiliaries or unless the fuel value is greater than 20 cents per million Btu.

It should be remembered that in addition to the above, other factors well may be significant. A high water content in the flue gas could improve the payout. In some areas reductions in noxious fumes may be sufficiently important to justify a payout longer than six years. Operating experience on about ten CO boiler units indicates that 5 percent to 10 percent more steam is produced from the CO gas than would be calculated. This is a result of entrained hydrocarbons which do not show up in the normal CO gas analysis.

Although the CO boiler is not a panacea in all plants, it may be a money-maker for you. Check the figures and decide for yourself if your plant can afford to be without a CO boiler.

Based on a paper originally presented at WPRA meeting, El Paso, Texas, May 22, 1958.

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[2]Durham, E. and Leland, M. B., "DESIGN AND APPLICATION OF CO BOILERS" presented to Sabine Section of ASME, Port Arthur, Texas, March 7, 1956.

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Applied Hydrocarbon Thermodynamics

Part 8
Polytropic Compression and Expansion

A calculation method is developed for estimating final temperature and work done for these operations.

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IF HEAT is added or removed during the compression or expansion of a gas, the resulting path is called *polytropic* to distinguish it from the *adiabatic* path. As in an adiabatic process, the polytropic process may be reversible or nonreversible, depending upon the design and operation of the machine compressing or expanding the gas. Only the reversible polytropic process will be discussed.

When only reversible mechanical work is involved, which is the case under current consideration, the heat, work, and enthalpy change relationship is given by the first law of thermodynamics

$$\Delta H = Q + \int V dP = Q - W. \qquad (8.1)$$

The ΔH term depends only on the terminal conditions, while the heat (added to gas when Q is positive) and work (done to gas when $\int VdP$ is positive) terms depend upon the path followed. The $\int VdP$ term includes the net work of receiving and delivering the gas as well as compressing or expanding it.

For an adiabatic process $Q = 0$ and the shaft work may be found from the enthalpy difference. This is not true for nonadiabatic reversible, i.e., polytropic, paths. Polytropic work can be found with sufficient accuracy by evaluating $\int VdP$ directly as will be shown later. The enthalpy change may be found from initial and final conditions. From values of ΔH and $\int VdP$, the value of Q may be found by Equation 8.1. These polytropic work and final temperature calculations require exponents defining temperature and volume changes with pressure.

The objective of this part is to develop a calculation method for estimating the final temperature for polytropic compression and expansion of gases for which no Mollier charts exist. The plots, calculations, and discussion are from previous work,[4] with revisions. Deviations from reversibility are outside the scope of this installment.

Changes in T and V with P. Polytropic changes of temperature and volume with changes in pressure are conveniently expressed by exponents, as given in Part 7

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n'-1}{n'}} \qquad (7.5)$$

and

$$P_1V_1^n = P_2V_2^n \qquad (7.6)$$

The manner in which volume changes with pressure, in gas compression and expansion, is indicated in Figure 8.1, which is a log-log plot of pressure versus volume for isentropic and isenthalpic paths of steam and ethane. Data for making the plot were taken from thermodynamic properties compilations of Keenan and Keyes[6] for steam and of Barkelew, Valentine, and Hurd[2] for ethane.

Referring to Figure 8.1, it will be noted that straight lines have been drawn through the points for both isenthalpic and isentropic paths. Straight lines on these scales are represented by Equation 7.6 for which the values of the exponent n are tabulated in the box on Figure 8.1. The values of the temperature change exponent, n′, are also given for comparison.

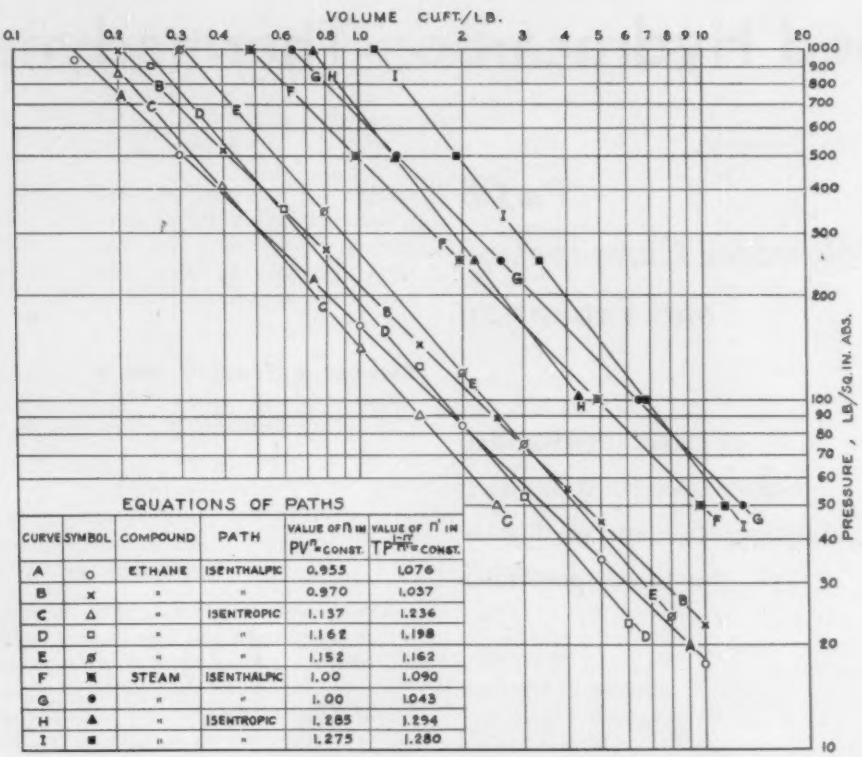
It will be noted that the temperature change exponent is always larger than the volume change exponent. Also, the isentropic exponents are appreciably larger than the corresponding isenthalpic exponents.

With isenthalpic and isentropic PV data forming straight lines on those scales for both ethane and steam, it appears reasonable to postulate straight lines for the intermediate polytropic paths and also for similar paths of other substances. Equations 7.5 and 7.6 may be considered applicable over limited ranges but not generally applicable for the entire range of pressure covered by Mollier diagrams. However, the normal pressure ranges of compressors and expanders are well within the limits of validity of Equations 7.5 and 7.6.

Adiabatic Efficiency. The following ratio, which is defined as the *adiabatic efficiency*, is proposed as a measure of the nearness of a reversible path to adiabatic conditions:

$$e_a = \frac{\Delta H}{\int VdP} \qquad (8.2)$$

For isentropic paths this ratio is unity while it is zero for



EQUATIONS OF PATHS

CURVE	SYMBOL	COMPOUND	PATH	VALUE OF n IN PV^n = CONST.	VALUE OF n' IN $TP^{\frac{n'-1}{n'}}$ = CONST.
A	○	ETHANE	ISENTHALPIC	0.955	1.076
B	×	"	"	0.970	1.037
C	△	"	ISENTROPIC	1.137	1.236
D	□	"	"	1.162	1.198
E	⌀	"	"	1.152	1.162
F	✱	STEAM	ISENTHALPIC	1.00	1.090
G	●	"	"	1.00	1.043
H	▲	"	ISENTROPIC	1.285	1.294
I	■	"	"	1.275	1.280

FIGURE 8.1—Plot of data for Isenthalpic and Isentropic paths of steam and ethane.

isenthalpic paths. This ratio is greater than unity for the addition of heat during reversible compression and for the removal of heat during reversible expansion. It is less than unity for the removal of heat during reversible compression and for the addition of heat during reversible expansion.

In other words, the ratio defined by Equation 8.2 is greater than unity when there is an increase in entropy and less than unity when there is a decrease in entropy during reversible gas compression, while the reverse is true for reversible expansion.

Combining Equations 8.1 and 8.2 to eliminate ΔH gives

$$e_a = 1 + \frac{Q}{\int V dP} \tag{8.3}$$

A convenient and adequate approximation for e_a is found by replacing $\int VdP$ in Equation 8.3 by a modified isothermal expression giving

$$e_a \simeq 1 + \frac{Q}{(RZT)_{ad.av.} \ln \left(\frac{P_2}{P_1}\right)} \tag{8.4}$$

where

$(RZT)_{ad.av.}$ = average of terminal values of RZT for adiabatic and reversible path (i.e., isentropic) having same initial conditions and final pressure as polytropic path in question.

The adiabatic efficiency, e_a, may also be defined in terms of the temperature change exponent, n′, defined by Equation 7.5 for any path. This temperature change exponent was shown previously to be the following for an isentropic path:

$$\frac{n'-1}{n'} = \frac{R\left[Z + T\left(\frac{\partial Z}{\partial T}\right)_P\right]}{C_p} \tag{7.12}$$

In a similar manner, an analogous equation may be derived for the isenthalpic path.

Expressing the relationship given in Equation 7.5 differentially for an isenthalpic path and solving for $(n'-1)/n'$ given

$$\frac{n'-1}{n'} = \left(\frac{\partial \ln T}{\partial \ln P}\right)_H = \frac{P}{T}\left(\frac{\partial T}{\partial P}\right)_H \tag{8.5}$$

Equation 8.5 is similar to Equation 7.8, the only difference being the constant H instead of constant S path.

The variables in Equation 8.5 will be transformed by defining H as a function of P and T giving

$$\left(\frac{\partial T}{\partial H}\right)_H = -\frac{\left(\frac{\partial H}{\partial P}\right)_T}{\left(\frac{\partial H}{\partial T}\right)_P} \tag{8.6}$$

where

$$\left(\frac{\partial H}{\partial P}\right)_T = \left[V - T\left(\frac{\partial V}{\partial T}\right)_P\right] = -\frac{RT^2}{P}\left(\frac{\partial Z}{\partial T}\right)_P \tag{8.7}$$

$$\left(\frac{\partial H}{\partial T}\right)_P = C_P \qquad (8.8)$$

Equations 8.7 and 8.8 were developed or defined previously in part 1 of this present series (January 1958).

Combining Equations 8.5, 8.6, 8.7, and 8.8 gives for an isenthalpic path

$$\frac{n'-1}{n'} = \frac{RT\left(\frac{\partial Z}{\partial T}\right)_P}{C_P} \qquad (8.9)$$

In reduced parameters, the numerator becomes $RT_r\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}$, (the units being the units of R, which is 1.9875 when C_P is Btu/lb mole °F). The numerator may be written $C_P^\circ + \Delta C_P$.

The similarity of Equations 7.12 and 8.9 suggests a single equation that applies to isentropic, isenthalpic, and to polytropic paths by using a factor defining the adiabatic nature of the path.

Adiabatic Efficiency—Temperature Exponent Relationship. An equation relating e_a and n' is obtained from Equation 8.3 by replacing Q with $\int Tds$, which is justified for the reversible path assumed here.

$$e_a = 1 + \frac{\int Tds}{\int VdP} \qquad (8.10)$$

For changes of infinitesimal length, Equation 8.10 may be written

$$e_a = 1 + \frac{Tds}{VdP} \qquad (8.11)$$

In applying Equation 8.11 to paths of finite length, mean values of the numerator and denominator should be used for the path giving

$$e_a = 1 + \frac{T_{av}\,\Delta S}{V_{av}\,\Delta P} \qquad (8.12)$$

Recognizing this limitation, Equation 8.11 will be used in the following derivations. Substituting

$$ds = \frac{C_P}{T}\,dt - \left(\frac{\partial V}{\partial T}\right)_P dp$$

from Equation 1.54, into Equation 8.11 and rearranging

$$e_a = 1 + \frac{C_P}{V}\left(\frac{dT}{dP}\right) - \frac{T}{V}\left(\frac{\partial V}{\partial T}\right)_P \qquad (8.13)$$

Replacing V and $(\partial V/\partial T)_P$ by equivalents in terms of compressibility factors:

$$V = \frac{ZRT}{P}$$

$$\left(\frac{\partial V}{\partial T}\right)_P = \frac{ZR}{P} + \frac{RT}{P}\left(\frac{\partial Z}{\partial T}\right)_P$$

This combination gives

$$e_a = \frac{C_P}{RZ}\left(\frac{d\,\ln T}{d\,\ln P}\right) - \frac{RT}{RZ}\left(\frac{\partial Z}{\partial T}\right)_P \qquad (8.14)$$

From Equation 7.5

$$\frac{d\,\ln T}{d\,\ln P} = \frac{n'-1}{n'}$$

Substituting the temperature exponent and changing to reduced units

$$e_a = \frac{(C_P^\circ + \Delta C_P)\left(\frac{n'-1}{n'}\right) - RT_r\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}}{ZR} \qquad (8.15)$$

Solving for $\frac{n'-1}{n'}$ gives the following general form of Equation 7.12 and 8.9

$$\frac{n'-1}{n'} = \frac{RZe_a + RT_r\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}}{C_P^\circ + \Delta C_P} \qquad (8.16)$$

The above shows the connection between Equations 8.2 and 8.14 It is obvious by inspection that the values of e_a in both equations will be unity for isentropic paths and zero for isenthalpic paths. It will be shown later, by numerical calculations, that e_a in Equation 8.16 is the same as e_a in Equation 8.2 for polytropic paths.

Equations 7.12 and 8.9 were derived for infinitesimal changes of T and P. Thus, these two equations and Equation 8.16 are rigorous only at points (defined by T and P) rather than paths. An integration of the differential form of Equation 7.5 with the exponent from Equation 8.16 for any path (isentropic or polytropic) would be hopelessly complex because all the terms in the exponent relation are functions of T and P. Therefore, averages or mean values will be used for paths.

Values of e_a by Equation 8.2, 8.4, and 8.15 will be computed for several paths and compared. Generalized values of ΔC_P, RZ, and $RT_r\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}$ for applying Equation 8.15 are given in Table 7.5. Values of ΔC_P° are given in Tables 7.3 and 7.4.

Compression and Expansion Paths. Having justified the representation of polytropic paths between isenthalpic and isentropic by the relationship PV^n = constant and having derived the equation for the exponent n′ and developed the compilations of generalized thermodynamic properties required in estimating the exponent, it is next of interest to look at these various paths on pressure-enthalpy-type Mollier diagrams and to check the proposed exponent method with available information.

Figure 8.2 is a section of P-H diagram for ethane with five compression paths indicated thereon. Figure 8.3 is a similar graph showing five similar expansion paths. These paths are given the letters: A, B, C, D, and E for easy identification in the tabulations reporting the results of computations. It will be noted that the isentropic paths are the same in both compression and expansion plots. With the isenthalpic path as the lower limit and the isentropic path, from the same initial point, as a guide or reference line, three polytropic paths were selected so that two were between the isenthalpic and isentropic paths and one beyond the isentropic path.

For each path shown on Figures 8.2 and 8.3, values of ΔH, Q, and ∫VdP have been computed and are tabulated in the corner of the diagrams. It is of interest to note the variations in the values of ΔH and Q for the five paths and the near constancy of the VdP values. From this it can be seen that serious errors would result from taking ΔH as the work for a polytropic path far

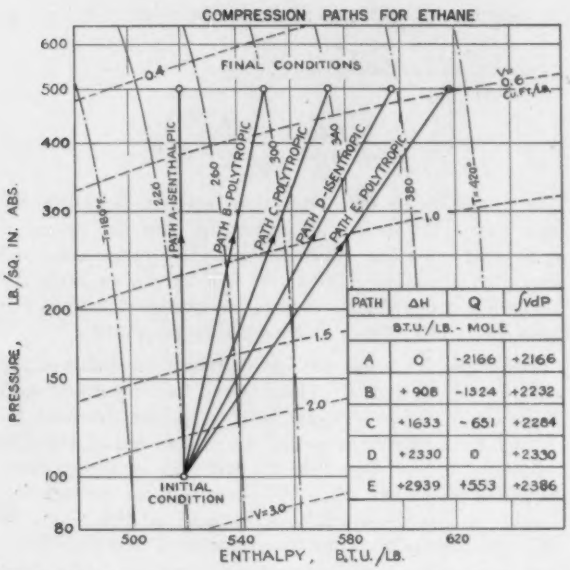


FIGURE 8.2—Section of ethane pressure—enthalpy diagram illustrating five compression paths.

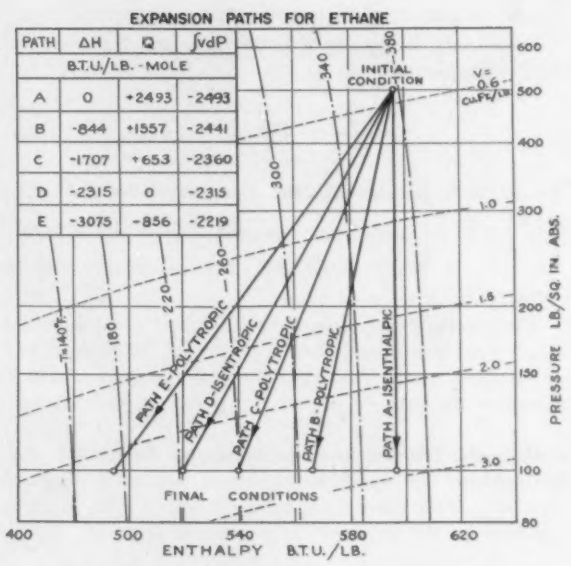


FIGURE 8.3—Section of ethane pressure—enthalpy diagram illustrating five expansion paths.

removed from the isentropic path. It should be clear from the information on Figures 8.2 and 8.3 that Mollier charts alone are not adequate for calculating the polytropic work.

Terminal conditions were chosen in the manner represented by Figures 8.2 and 8.3 for paths C, D, and E of nine different substances, for which suitable compilations of thermodynamic properties were available in the literature when the work reported here was first done.[4] For each substance, two groups of compression paths and two groups of expansion paths were selected. Data obtained in this manner are tabulated in Tables 8.1 and 8.2. This numerical work was limited to Paths C, D, and E because these are of the most practical interest. Rarely, in a reversible process, does the path fall outside this range.

Initial and final temperatures and pressures, both specific and reduced, are given in Table 8.1 for all paths read. The values of volumes, entropies, and enthalpies are given in Table 8.2.

Exponent calculations are given in Table 8.3 (also illustrated by the sample calculations in Table 8.4). The ratios of terminal pressure, temperature, and volume are included. Values of the exponents n′ and n, as defined by Equations 7.5 and 7.6, were computed and tabulated in Table 8.3.

A few comments about these exponents might be of interest:

a. Values of n′ are larger than the corresponding values of n.

b. Exponents for polytropic Path E are larger than the corresponding exponents for adiabatic Path D.

c. Exponents for polytropic Path C are smaller than the corresponding exponents for adiabatic Path D.

Calculation of Q and ∫VdP. The values of Q, the heat added, and other data for estimating e_a, the adiabatic efficiency, were computed for all the compression and expansion paths covered by the data in Tables 8.1 and 8.2. These calculations are illustrated in Table 8.4 for C_2H_6 expansion and CH_3Cl compression.

The exponents, n and n′, were found from the terminal P, V, and T values of the paths. These exponents values, which are tabulated in Table 8.3, were used in later calculations.

Values of generalized properties at the terminal conditions were read from Tables 7.3, 7.4, and 7.5 or from the charts for these propertes (i.e., RZ, $RT_r\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}$, C_P°, and ΔC_P). Samples of these generalized data are given in Table 8.4. Similar data for all the other paths are not listed because of the space this tabulation would occupy.

Q, the quantity of heat added during compression or expansion, was computed for each path by the first law relationship, Equation 8.1. This calculation requires the values of ΔH and W_s. The enthalpy differences were found in the Mollier chart readings in Table 8.2. These ΔH values are listed in Table 8.5 in Btu/pound mole for each path. Work quantities were computed by integrating ∫VdP over PV^n = constant with n values being the values found by applying Equation 7.6 to the terminal P and V values. (These n values are given in Table 8.3.)

This direct integration of VdP along a PV^n = constant path gives

$$\int_1^2 VdP = \left(\frac{n}{n-1}\right)\Delta(PV) = \frac{n}{n-1}P_1V_1\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] \quad (8.17)$$

The P_1V_1 product in Equation 8.17 may be replaced by $(RZT)_1$. The units of work in Equation 8.17 are

TABLE 8.1—Terminal Pressures and Temperatures for Compression and Expansion Paths

Subs't and Ref.	Operation	Group	Pressures, lb/sq in. Abs.		TEMPERATURES, °F.				Reduced Pressures, Pr		REDUCED TEMPERATURES, Tr.			
						Final						Final		
			Initial	Final	Initial	Path C	Path D	Path E	Initial	Final	Initial	Path C	Path D	Path E
H_2O	Compression	I	500	2000	570	900	955	1000	0.156	0.624	0.884	1.170	1.217	1.255
	Compression	II	150	1300	400	800	955	1100	0.047	0.405	0.740	1.084	1.217	1.342
(6)	Expansion	III	2000	500	955	660	570	470	0.624	0.156	1.217	0 964	0.884	0.800
	Expansion	IV	1300	150	955	540	400	360	0.405	0.047	1.217	0.860	0.740	0.705
NH_3	Compression	I	28	100	150	280	347	390	0.017	0.067	0.835	1.040	1.105	1.164
	Compression	II	50	300	50	250	305	360	0.03	0.183	0.700	0.9725	1.048	1.123
(1)	Expansion	III	100	28	347	220	150	100	0.067	0.017	1.105	0.931	0.835	0.767
	Expansion	IV	300	50	305	120	50	25	0.183	0.03	1.048	0.795	0.700	0.664
SO_2	Compression	I	200	1000	180	400	440	500	0.1755	0.878	0.826	1.110	1.161	1.239
	Compression	II	60	300	200	370	446	500	0.0526	0.263	0.852	1.071	1.170	1.239
(8)	Expansion	III	1000	200	440	240	180	160	0.878	0.1755	1.161	0.903	0.826	0.800
	Expansion	IV	300	60	446	270	200	140	0.263	0.0526	1.170	0.942	0.852	0.775
CH_4	Compression	I	80	400	—170	—60	—20	20	0.119	0.594	0.844	1.162	1.280	1.396
	Compression	II	80	250	—70	20	57	80	0.119	0.371	1.133	1.396	1.503	1.570
(7)	Expansion	III	400	80	—20	—130	—170	—200	0.594	0.119	1.280	0.960	0.843	0.756
	Expansion	IV	250	80	57	—30	—70	—100	0.371	0.119	1.503	1.250	1.133	1.048
C_2H_4	Compression	I	294	882	20	140	154	180	0.392	1.177	0.941	1.177	1.203	1.255
	Compression	II	147	735	100	240	290	340	0.196	0.980	1.100	1.372	1.470	1.569
(10)	Expansion	III	882	294	154	40	20	0	1.177	0.392	1.203	0.980	0.941	0.902
	Expansion	IV	735	147	290	160	100	80	0.980	0.196	1.470	1.215	1.138	1.059
C_2H_6	Compression	I	100	800	0	180	209	230	0.141	1.128	0.836	1.163	1.218	1.255
	Compression	II	100	500	220	340	377	410	0.141	0.705	1.237	1.455	1.523	1.582
(2)	Expansion	III	800	100	209	50	0	—40	1.128	0.141	1.218	0.9275	0.836	0.764
	Expansion	IV	500	100	377	260	220	170	0.705	0.141	1.523	1.309	1.237	1.145
CH_3Cl	Compression	I	100	260	171	270	297	340	0.1035	0.269	0.844	0.976	1.012	1.070
	Compression	II	26	200	89	270	344	440	0.027	0.207	0.735	0.976	1.075	1.203
(9)	Expansion	III	260	100	297	200	171	140	0.269	0.1035	1.012	0.883	0.844	0.802
	Expansion	IV	200	26	344	160	89	20	0.207	0.027	1.074	0.829	0.735	0.642
CCl_2F_2	Compression	I	36	200	100	200	230	260	0.062	0.344	0.809	0.954	0.996	1.040
	Compression	II	50	220	231	320	350	380	0.086	0.378	0.998	1.127	1.170	1.213
(3)	Expansion	III	200	36	230	130	100	70	0.344	0.062	0.996	0.842	0.809	0.765
	Expansion	IV	220	50	350	270	231	200	0.378	0.086	1.170	1.054	0.998	0.953
$CHClF_2$	Compression	I	55	240	60	170	202	240	0.077	0.335	0.782	0.947	0.995	1.052
	Compression	II	50	260	200	320	366	400	0.07	0.363	0.992	1.172	1.242	1.293
(5)	Expansion	III	240	55	202	100	60	30	0.335	0.077	0.995	0.842	0.782	0.737
	Expansion	IV	260	50	366	250	200	150	0.363	0.07	1.242	1.069	0.992	0.917

TABLE 8.2—H, S, and V Readings for Compression and Expansion Paths

Subs't and Ref.	Operation	Group	VOLUMES, CU FT/LB				ENTHALPIES, BTU/LB				ENTROPIES, BTU/LB °F			
				Final				Final				Final		
			Initial	Path C	Path D	Path E	Initial	Path C	Path D	Path E	Initial	Path C	Path D	Path E
H_2O	Compression	I	1.1122	0.3532	0.3758	0.3935	1279.5	1409.2	1445.0	1474.5	1.540	1.5139	1.540	1.5603
	Compression	II	3.223	0.5131	0.6023	0.6816	1219.4	1374.3	1468.4	1553.9	1.5995	1.5296	1.5995	1.6572
(6)	Expansion	III	0.3758	1.2478	1.122	0.934	1445.0	1334.2	1279.5	1207.2	1.54	1.5915	1.540	1.4662
	Expansion	IV	0.6023	3.856	3.223	3.023	1468.4	1295.0	1219.4	1195.1	1.5995	1.6811	1.5995	1.5706
NH_3	Compression	I	13.56	4.562	5.00	5.25	693.7	759.4	798.0	823.0	1.4994	1.4507	1.4994	1.530
	Compression	II	6.20	1.372	1.52	1.639	636.0	726.5	761.5	795.3	1.330	1.2827	1.33	1.3729
(1)	Expansion	III	5.00	15.2	13.56	12.4	798.0	731.0	693.7	667.5	1.4994	1.558	1.4994	1.455
	Expansion	IV	1.52	7.1	6.2	5.8	761.5	675.0	636	620	1.330	1.40	1.330	1.295
SO_2	Compression	I	0.464	0.1076	0.1190	0.1345	222.0	244.2	253.9	267.1	0.3998	0.3888	0.3998	0.4147
	Compression	II	1.78	0.426	0.475	0.509	231.2	255.4	269.5	279.7	0.4501	0.4338	0.4501	0.4611
(8)	Expansion	III	0.1190	0.531	0.464	0.441	253.9	233.5	222.0	218.1	0.3998	0.4172	0.3998	0.3935
	Expansion	IV	0.475	1.98	1.78	1.59	269.5	243.5	231.2	221.7	0.4501	0.4672	0.4501	0.4334
CH_4	Compression	I	2.252	0.579	0.664	0.744	276.1	315.8	340.0	363.9	1.147	1.0887	1.147	1.1976
	Compression	II	3.167	1.226	1.334	1.402	329.3	369.9	390.0	403.4	1.3054	1.2642	1.3054	1.3294
(7)	Expansion	III	0.664	2.633	2.252	1.954	340.0	297.6	276.1	259.5	1.147	1.2179	1.147	1.0832
	Expansion	IV	1.334	3.521	3.167	2.903	390.0	350.1	329.3	313.5	1.3054	1.3563	1.3054	1.2635
C_2H_4	Compression	I	0.503	0.186	0.200	0.219	242.5	267.8	276.0	291.2	0.582	0.568	0.582	0.607
	Compression	II	1.382	0.321	0.355	0.389	286.5	329.2	355.5	382.4	0.711	0.674	0.711	0.745
(10)	Expansion	III	0.200	0.545	0.503	0.459	276.0	252.1	242.5	232.5	0.582	0.591	0.582	0.560
	Expansion	IV	0.355	1.556	1.382	1.324	355.5	311.6	286.5	278.4	0.711	0.753	0.711	0.696
C_2H_6	Compression	I	1.484	0.2089	0.2324	0.2478	418.4	463.0	482.5	496.3	1.6234	1.5939	1.6234	1.6434
	Compression	II	2.366	0.5329	0.5637	0.5910	520.2	574.5	597.7	617.9	1.8046	1.7760	1.8046	1.8277
(2)	Expansion	III	0.2324	1.700	1.484	1.298	482.5	440.3	418.4	400.6	1.6234	1.6692	1.6234	1.5809
	Expansion	IV	0.5637	2.517	2.366	2.176	597.7	540.9	520.2	495.4	1.8046	1.8341	1.8046	1.7667
CH_3Cl	Compression	I	1.246	0.528	0.557	0.601	225.6	242.14	248.7	261.35	0.4205	0.4108	0.4205	0.4359
	Compression	II	4.353	0.708	0.802	0.918	212.95	245.02	264.5	290.52	0.4496	0.4240	0.4496	0.4800
(9)	Expansion	III	0.557	1.318	1.246	1.165	248.7	232.50	225.6	218.15	0.4205	0.4312	0.4205	0.4084
	Expansion	IV	0.802	4.969	4.353	3.737	264.5	227.86	212.95	199.15	0.4496	0.4750	0.4496	0.4227
CCl_2F_2	Compression	I	1.332	0.252	0.272	0.290	92.22	103.13	108.58	114.16	0.19192	0.18388	0.19192	0.19967
	Compression	II	1.202	0.293	0.309	0.325	112.79	124.70	130.42	136.21	0.21960	0.21244	0.21960	0.22665
(3)	Expansion	III	0.272	1.412	1.332	1.250	108.58	96.82	92.2	87.74	0.19192	0.19991	0.19192	0.18369
	Expansion	IV	0.309	1.277	1.202	1.142	130.42	119.44	112.79	107 62	0.21960	0.22898	0.21960	0.21196
$CHClF_2$	Compression	I	1.0921	0.2705	0.2936	0.3196	113.28	125.06	131.14	138.32	0.2391	0.2297	0.2391	0.2496
	Compression	II	1.578	0.3404	0.3666	0.3858	136.05	153.37	162.58	169.57	0.2798	0.2683	0.2798	0.2881
(5)	Expansion	III	0.2936	1.1902	1.0921	1.0176	131.14	119.50	113.28	108.76	0.2391	0.2505	0.2391	0.2300
	Expansion	IV	0.3666	1.707	1.578	1.448	162.58	144.76	136.05	127.68	0.2798	0.2925	0.2798	0.2666

TABLE 8.3—Exponent Calculations for Compression and Expansion Paths

Subs't and Ref.	Operation	Group	Pressure Ratio, P_2/P_1	TEMPERATURE RATIO, T_2/T_1			VOLUME RATIO V_1/V_2			TEMPERATURE EXPONENT, n′			VOLUME EXPONENT n		
				Path C	Path D	Path E	Path C	Path D	Path E	Path C	Path D	Path E	Path C	Path D	Path E
H_2O	Compression	I	4.0	1.320	1.372	1.4175	3.145	2.96	2.825	1.251	1.295	1.336	1.210	1.278	1.336
	Compression	II	8.67	1.465	1.642	1.814	6.285	5.35	4.73	1.215	1.298	1.380	1.175	1.288	1.390
(6)	Expansion	III	0.25	0.791	0.728	0.6575	0.301	0.3378	0.4023	1.240	1.297	1.430	1.155	1.278	1.523
	Expansion	IV	0.1155	0.707	0.608	0.5795	0.1564	0.187	0.194	1.191	1.299	1.339	1.166	1.289	1.315
NH_3	Compression	I	3.57	1.213	1.323	1.394	0.1517	0.2199	0.2609	1.179	1.282	1.3535	1.167	1.278	1.340
	Compression	II	6.00	1.392	1.50	1.607	0.1846	0.2263	0.2648	1.226	1.293	1.360	1.188	1.274	1.346
(1)	Expansion	III	0.28	0.843	0.756	0.694	0.329	0.3688	0.4033	1.155	1.282	1.403	1.143	1.277	1.400
	Expansion	IV	0.1667	0.758	0.6665	0.635	0.2140	0.2451	0.2621	1.184	1.2935	1.340	1.161	1.273	1.340
SO_2	Compression	I	5.0	1.344	1.406	1.50	4.312	3.90	3.45	1.225	1.268	1.336	1.1015	1.183	1.300
	Compression	II	5.0	1.257	1.373	1.455	4.154	3.727	3.476	1.166	1.245	1.304	1.130	1.227	1.292
(8)	Expansion	III	0.2	0.7775	0.711	0.689	0.224	0.2565	0.2698	1.185	1.269	1.301	1.075	1.183	1.230
	Expansion	IV	0.2	0.806	0.7285	0.662	0.240	0.267	0.2989	1.186	1.245	1.340	1.128	1.220	1.334
CH_4	Compression	I	5.0	1.380	1.518	1.655	3.885	3.39	3.025	1.25	1.35	1.455	1.187	1.32	1.455
	Compression	II	3.12	1.230	1.326	1.385	2.585	2.375	2.26	1.223	1.330	1.402	1.197	1.315	1.395
(7)	Expansion	III	0.20	0.750	0.659	0.5905	0.2523	0.295	0.340	1.218	1.350	1.487	1.169	1.319	1.490
	Expension	IV	0.32	0.832	0.754	0.696	0.3789	0.4212	0.4595	1.192	1.330	1.466	1.173	1.316	1.465
C_2H_4	Compression	I	3.0	1.249	1.278	1.332	2.703	2.515	2.296	1.254	1.287	1.354	1.105	1.19	1.321
	Compression	II	5.0	1.206	1.292	1.378	4.304	3.890	3.55	1.132	1.189	1.249	1.103	1.185	1.271
(10)	Expansion	III	0.333	0.814	0.782	0.749	0.367	0.3975	0.436	1.230	1.288	1.356	1.098	1.191	1.325
	Expansion	IV	0.20	0.826	0.773	0.720	0.2282	0.257	0.2682	1.135	1.191	1.256	1.090	1.185	1.223
C_2H_6	Compression	I	8	1.391	1.455	1.500	7.105	6.385	5.99	1.189	1.221	1.243	1.060	1.122	1.162
	Compression	II	5	1.176	1.231	1.279	4.44	4.198	4.002	1.112	1.148	1.181	1.080	1.122	1.160
(2)	Expansion	III	0.125	0.763	0.688	0.628	0.1368	0.1568	0.1792	1.1495	1.220	1.289	1.046	1.122	1.209
	Expansion	IV	0.20	0.8605	0.8125	0.753	0.2240	0.2383	0.2590	1.103	1.1485	1.215	1.076	1.123	1.222
CH_3Cl	Compression	I	2.60	1.157	1.200	1.2675	2.36	2.238	2.073	1.180	1.2355	1.330	1.113	1.1655	1.311
	Compression	II	7.695	1.330	1.465	1.640	6.01	5.30	4.634	1.1625	1.227	1.320	1.1375	1.2235	1.330
(9)	Expansion	III	0.3845	0.872	0.8335	0.7925	0.4225	0.447	0.478	1.167	1.235	1.321	1.110	1.188	1.294
	Expansion	IV	0.13	0.771	0.6825	0.597	0.1615	0.18435	0.21485	1.146	1.230	1.338	1.119	1.208	1.329
CCl_2F_2	Compression	I	5.555	1.179	1.232	1.286	5.285	4.898	4.591	1.106	1.1385	1.172	1.03	1.08	1.125
	Compression	II	4.40	1.129	1.1725	1.215	4.105	3.89	3.70	1.089	1.120	1.151	1.050	1.091	1.133
(3)	Expansion	III	0.18	0.855	0.8115	0.766	0.1926	0.2042	0.2176	1.1005	1.1385	1.184	1.041	1.08	1.125
	Expansion	IV	0.2273	0.9015	0.8530	0.815	0.2420	0.2570	0.2705	1.075	1.120	1.16	1.045	1.091	1.133
$CHClF_2$	Compression	I	4.365	1.2115	1.273	1.346	4.039	3.72	3.419	1.15	1.1955	1.252	1.056	1.122	1.199
	Compression	II	5.20	1.182	1.251	1.303	4.632	4.402	4.09	1.113	1.156	1.191	1.076	1.112	1.171
(5)	Expansion	III	0.2292	0.846	0.786	0.740	0.2468	0.2689	0.2885	1.1275	1.195	1.256	1.054	1.121	1.186
	Expansion	IV	0.1923	0.866	0.799	0.744	0.2148	0.2323	0.2532	1.095	1.151	1.219	1.071	1.130	1.200

TABLE 8.4—Sample Calculations of Exponents Heat Added and Adiabatic Efficiency Factor

H-S Chart or Table Data	C_2H_6 EXPANSION				CH_3Cl COMPRESSION			
		Final or Average for Path				Final or Average for Path		
	Initial	C	D	E	Initial	C	D	E
Temperature, °F	377	260	200	170	89	270	344	440
Pressure, psia	500	100	100	100	26	200	200	200
Volume, cu ft/lb.	0.5637	2.517	2.366	2.176	4.253	0.708	0.802	0.918
Enthalpy, Btu/lb.	597.7	540.9	520.2	495.4	212.95	245.02	264.50	290.52
Exponent Calculation								
n in $P_2/P_1 = (V_1/V_2)^n$	.....	1.076	1.123	1.222	.....	1.1375	1.2235	1.330
n′ in $T_2/T_1 = (P_2/P_1)^{(n'-1)/n'}$	.....	1.103	1.1485	1.215	.....	1.1625	1.227	1.320
Generalized Data								
T_r	1.523	1.309	1.237	1.145	0.735	1.976	1.075	1.203
P_r	0.705	0.141	0.141	0.141	0.027	0.207	0.207	0.207
ZR	1.870	1.945	1.940	1.920	1.93	1.81	1.86	1.905
$RT_r \left(\frac{\partial Z}{\partial T_r}\right) P_r$	0.38	0.165	0.180	0.230	0.16	0.59	0.43	0.295
C_P°	17.55	15.60	14.96	14.13	9.83	11.60	12.28	13.20
ΔC_P	0.86	0.28	0.335	0.44	0.62	1.70	0.86	0.56
$C_P = C_P^\circ + \Delta C_P$	18.41	15.88	15.30	14.57	10.45	13.30	13.14	13.76
Heat Added								
ΔH, Btu/lb. mole	.....	−1707	−2330	−3075	.....	+1618	+2602	+3916
(n−1)/n	.....	0.0706	0.1087	0.1824	.....	0.1209	0.1827	0.248
$(P_2/P_1)^{(n-1)/n}$	.....	0.8926	0.8395	0.7456	.....	1.2796	1.452	1.658
$-W_s = \int V dP = Z_1 RT_1 \frac{n}{n-1}$								
$\left[(P_2/P_1)^{\frac{n-1}{n}} - 1\right]$	.....	−2360	−2298	−2219	.....	+2451	+2580	+2748
$Q = \Delta H + W_s$	.....	+ 653	− 32	− 856	.....	− 833	+ 22	+1168
Q (adjusted)	.....	+ 685	0	− 824	.....	− 855	0	+1146
$-W_s$ (adjusted)	.....	−2392	−2330	−2251	.....	+2473	+2602	+2770
Adiabatic Efficiency Factor								
$e_a = \Delta H / \int V dP$	.....	0.714	1.0	1.365	.....	0.654	1.0	1.413
$(n'-1)/n'$	.....	0.093	0.129	0.1762	.....	0.1398	0.1892	0.2425
$(C_P^\circ + \Delta C_P)_{mean}$	.....	17.145	16.853	16.49	.....	11.875	11.795	12.105
$[RT_r (\partial Z / \partial T_r)_{P_r}]_{mean}$	.....	0.2725	0.280	0.305	.....	0.375	0.295	0.2275
$[ZR]_{mean}$	.....	1.908	1.905	1.895	.....	1.87	1.895	1.9175
$e_a = \left[\frac{\left(\frac{n'-1}{n'}\right)(C_P^\circ + \Delta C_P) - RT_r \left(\frac{\partial T_r}{\partial Z}\right) P_r}{ZR}\right]_{mean}$	.....	0.693	0.993	1.372	.....	0.687	1.010	1.412
Avg. Temp. for Ad. Path D, °R.	.....	.....	749	.....	.....	.....	677	.....
$(ZRT)_{Ad.\ Avg} \ln P_2/P_1$	.....	.....	−2300	.....	.....	.....	+2618	.....
$e_a = 1.0 + \frac{Q\ (\text{Adjusted})}{(ZRT)_{Ad.\ Avg} \ln P_2/P_1}$	.....	0.704	1.0	1.358	.....	0.672	1.0	1.440

determined by the units of P_1V_1 or $(RZT)_1$, i.e., foot pounds per cubic foot or Btu/pound mole of gas.

Equation 8.17 is valid for any path defined by PV^n = constant, regardless of the value of the exponent, for actual gases as well as perfect gases. There is a widespread misconception that Equation 8.17 depends upon the perfect gas law because it is often derived for perfect gas conditions. PV^n = constant is a necessary and sufficient condition for the validity of Equation 8.17 regardless of the approach to perfect gas behavior.

Using Equations 8.17 and the values of n in Table 8.3, the work quantities were computed for each path. (See Table 8.4 for two samples of this calculation.) Q was then found as the algebraic sum of ΔH and W_s, as shown in Table 8.5. The values of Q for the adiabatic paths D were not exactly equal to zero as they should be.

Therefore, adjustments were made to the Q and $\int VdP$ values to make $Q = 0$ and $\Delta H = \int VdP$ for Path D, the isentropic or reversible and adiabatic process. The values of these corrections are listed in Table 8.5. The positive sign indicates that the correction was added to the calculated $\int VdP$ and Q values for Paths C, D, and E, while a negative sign indicates that the correction was subtracted. This is illustrated in Table 8.4 for both compression and expansion.

Values of ΔH, $\int VdP$, and Q for the two polytropic paths (i.e., Paths C and F) are given in Table 8.5. The $\int VdP$ and Q values are adjusted as described above. For Path D, where $\Delta H = \int VdP$, by definition, only the ΔH values and the corrections to Q and $\int VdP$ are given.

The spread in $\int VdP$ from Path C to Path E is relatively small compared to the corresponding spread in ΔH. The average spread in $\int VdP$ from Path C to Path E is 7% of the $\int VdP$ for the isentropic Path D. The comparable spread for ΔH is 60 percent of the $\Delta H = \int VdP$ for the isentropic Path D. These variations are offset by changes in Q. The enthalpy, work, and heat quantities, illustrated by those given in Table 8.5, are used in calculating the adiabatic efficiencies.

Adiabatic Efficiencies. Values of e_a were next computed by the three methods (i.e., Equations 8.2, 8.4, and 8.15) developed previously. The results are given in Table 8.6. Values of e_a from Equations 8.2 and 8.4 are given for Paths C and E only as e_a values from Equations 8.2 and 8.4 were made unity for Path D by adjusting Q and $\int VdP$.

Equation 8.15 results are given for all three paths. These back-calculated e_a values are not unity for Path D as they should be. Except for two cases, they are within ± 10%, however. When the e_a value is low (or high) for Path D, e_a is low (or high) by a corresponding amount for Paths C and E.

These consistent errors are probably due to using average properties for the path plus the inherent inaccuracies involved in back-calculating the temperature change exponents for Mollier chart readings at the terminals of the paths.

Demonstration Calculations. Using values of e_a found by Equation 8.4 (resulting values of e_a are given in Table 8.5) and exponents by Equation 8.16, temperature changes were computed by Equation 7.5 for all 36 paths used in previous calculations. These calculated temperature changes are listed along with the observed ΔT values in Table 8.7. Deviations of the calculated from observed ΔT values are also given.

The agreement of calculated ΔT values for these reversible compression and expansion by the proposed

TABLE 8.5—Calculation of Heat Absorbed by Polytropic Compression and Expansion Paths

Subs't and Ref.	Operation	Group	POLYTROPIC PATH C			ADIABATIC PATH D		POLYTROPIC PATH E		
			ΔH	∫vdP	Q	ΔH = ∫vdP	Correction to Q	ΔH	∫vdP	Q
H_2O (6)	Compression	I	+2340	+2920	− 580	+2980	+60	+3510	+3038	+ 472
	Compression	II	+2790	+4123	−1333	+4490	+50	+6030	+4806	+1224
	Expansion	III	−1996	−3086	+1090	−2980	+20	−4282	−2690	−1392
	Expansion	IV	−3123	−4791	+1668	−4490	+33	−4927	−4393	− 533
NH_3 (1)	Compression	I	+1119	+1698	− 579	+1775	+21	+2200	+1824	+ 377
	Compression	II	+1542	+2043	− 501	+2138	− 1	+2711	+2243	+ 468
	Expansion	III	−1141	−1848	+ 707	−1775	−35	−2222	−1689	− 524
	Expansion	IV	−1474	−2261	+ 787	−2138	− 9	−2410	−2088	− 322
SO_2 (8)	Compression	I	+1423	+1965	− 542	+2044	+42	+2890	+2154	+ 736
	Compression	II	+1551	+2343	− 792	+2453	+78	+3109	+2528	+ 581
	Expansion	III	−1318	−2097	+ 779	−2044	−29	−2294	−1970	− 324
	Expansion	IV	−1666	−2543	+ 877	−2453	−108	−3063	−2355	− 708
CH_4 (7)	Compression	I	+ 638	+ 972	− 334	+1025	+ 6	+1405	+1073	+ 332
	Compression	II	+ 650	+ 937	− 287	+ 973	− 5	+1185	+1095	+ 90
	Expansion	III	− 678	−1169	+ 491	−1025	+45	−1290	−1071	− 219
	Expansion	IV	− 638	−1021	+ 393	− 973	+21	−1225	− 937	− 288
C_2H_4 (10)	Compression	I	+ 710	+ 932	− 221	+ 940	+48	+1366	+ 961	+ 405
	Compression	II	+1198	+1874	− 676	+1936	−54	+2690	+2010	+ 680
	Expansion	III	− 671	− 950	+ 279	− 940	+ 4	−1221	−1025	− 196
	Expansion	IV	−1232	−2000	+ 768	−1936	− 1	−2163	−1876	− 387
C_2H_6 (2)	Compression	I	+1340	+1876	− 536	+1926	− 4	+2342	+1952	+ 390
	Compression	II	+1633	+2280	− 647	+2330	− 4	+2939	+2380	+ 559
	Expansion	III	−1268	−1987	+ 719	−1926	−22	−2462	−1870	− 592
	Expansion	IV	−1707	−2392	+ 685	−2330	−32	−3075	−2251	− 824
CH_3Cl (9)	Compression	I	+ 835	+1147	− 360	+1167	−27	+1805	+1195	+ 610
	Compression	II	+1618	+2473	− 855	+2602	+22	+3916	+2770	+1146
	Expansion	III	− 818	−1188	+ 370	−1167	+31	−1543	−1141	− 402
	Expansion	IV	−1851	−2465	+ 614	−2602	−21	−3300	−2746	− 544
CCl_2F_2 (3)	Compression	I	+1320	+1948	− 628	+1979	+12	+2641	+2018	+ 623
	Compression	II	+1440	+2098	− 658	+2131	+53	+2831	+2163	+ 668
	Expansion	III	−1423	−1998	+ 575	−1979	−112	−2520	−1941	− 579
	Expansion	IV	−1328	−2179	+ 851	−2131	−90	−2758	−2099	− 659
$CHClF_2$ (5)	Compression	I	+1019	+1512	− 493	+1545	−20	+2166	+1583	+ 583
	Compression	II	+1498	+2237	− 739	+2296	−15	+2900	+2343	+ 557
	Expansion	III	−1007	−1581	+ 574	−1545	−12	−1935	−1510	− 425
	Expansion	IV	−1542	−2367	+ 825	−2296	−23	−3019	−2220	− 799

TABLE 8.6—Adiabatic Efficiencies for Polytropic Paths by Alternate Methods

			EQUATION 8.2		EQUATION 8.4			EQUATION 8.15		
			$e_a = \frac{\Delta H}{\int v dP}$		$e_a = 1.0 + \frac{Q}{ZRT \ln P_2/P_1}$			$e_a = \frac{\left(\frac{n'-1}{n'}\right)(C_P^\circ + C_P) - RT_r\left(\frac{\delta Z}{\delta T_r}\right)_{P_r}}{ZR}$		
Subs't and Ref.	Operation	Group	Path C	Path E	ZRT ln P_2/P_1	Path C	Path E	Path C	Path D	Path E
H_2O (6)	Compression	I	0.800	1.155	+2985	0.806	1.158	0.780	0.96	1.124
	Compression	II	0.677	1.255	+4590	0.710	1.266	0.603	0.986	1.246
	Expansion	III	0.648	1.592	—2985	0.635	1.467	0.574	0.977	1.432
	Expansion	IV	0.652	1.121	—4590	0.637	1.116	0.630	0.985	1.110
NH_3 (1)	Compression	I	0.659	1.206	+1757	0.670	1.214	0.667	1.010	1.223
	Compression	II	0.754	1.209	+2166	0.769	1.216	0.792	1.008	1.215
	Expansion	III	0.617	1.310	—1757	0.598	1.298	0.700	1.010	1.316
	Expansion	IV	0.652	1.155	—2166	0.637	1.149	0.653	1.009	1.148
SO_2 (8)	Compression	I	0.724	1.341	+2031	0.733	1.362	0.610	0.907	1.244
	Compression	II	0.662	1.230	+2380	0.667	1.244	0.609	0.936	1.142
	Expansion	III	0.629	1.165	—2031	0.617	1.160	0.488	0 909	1.057
	Expansion	IV	0.655	1.301	—2380	0.632	1.298	0.655	0.936	1.263
CH_4 (7)	Compression	I	0.656	1.310	+1058	0.684	1.314	0.587	0.966	1.302
	Compression	II	0.694	1.082	+ 994	0.711	1.090	0.676	1.000	1.135
	Expansion	III	0.580	1.204	—1058	0.536	1.207	0.588	0.99	1.35
	Expansion	IV	0.625	1.307	— 994	0.605	1.290	0.624	1.008	1.305
C_2H_4 (10)	Compression	I	0.762	1.422	+ 923	0.761	1.439	0.880	1.102	1.522
	Compression	II	0.639	1.339	+1946	0.653	1.349	0.482	0.855	1.216
	Expansion	III	0.707	1.192	— 923	0.698	1.212	0.737	1.117	1.535
	Expansion	IV	0.616	1.154	—1946	0.605	1.199	0.594	0.860	1.169
C_2H_6 (2)	Compression	I	0.714	1.200	+1952	0.726	1.200	0.724	1.024	1.190
	Compression	II	0.716	1.234	+2300	0.719	1.243	0.698	1.00	1.244
	Expansion	III	0.638	1.318	—1952	0.632	1.303	0.576	1.012	1.430
	Expansion	IV	0.714	1.365	—2300	0.704	1.358	0.693	0.993	1.372
CH_3Cl (9)	Compression	I	0.727	1.510	+1202	0.700	1.508	0.767	1.047	1.458
	Compression	II	0.654	1.413	+2608	0.672	1.440	0.687	1.010	1.412
	Expansion	III	0.689	1.352	—1202	0.692	1.335	0.728	1.047	1.409
	Expansion	IV	0.751	1.202	—2608	0.764	1.209	0.663	1.009	1.364
CCl_2F_2 (3)	Compression	I	0.678	1.309	+1927	0.674	1.323	0.736	1.057	1.410
	Compression	II	0.687	1.308	+2065	0.681	1.323	0.708	1.034	1.336
	Expansion	III	0.712	1.298	—1927	0.702	1.300	0.722	1.061	1.450
	Expansion	IV	0.610	1.315	—2065	0.588	1.319	0.611	1.027	1.385
$CHClF_2$ (5)	Compression	I	0.674	1.368	+1559	0.684	1.374	0.750	1.063	1.404
	Compression	II	0.670	1.237	+2313	0.680	1.241	0.664	0.990	1.222
	Expansion	III	0.638	1.281	—1559	0.632	1.273	0.641	1.056	1.411
	Expansion	IV	0.652	1.360	—2313	0.643	1.345	0.591	0.953	1.348

TABLE 8.7—Demonstration of Proposed Method for Calculating Polytropic Temperature Changes

			PATH C-POLYTROPIC			PATH D-ISENTROPIC			PATH E-POLYTROPIC		
			T, °F			T, °F			T, °F		
Subs't	Operation	Group	Calc.	Obs.	% Dev.	Calc.	Obs.	% Dev.	Calc.	Obs.	% Dev.
H_2O	Compression	I	340	330	3.0	391	385	1.6	438	430	2.0
	Compression	II	428	400	7.0	561	555	1.1	715	700	2.1
	Expansion	III	—298	—295	1.0	—390	—385	1.3	—503	—485	3.7
	Expansion	IV	—410	—415	— 1.2	—559	—555	0.8	—595	—595	0
NH_3	Compression	I	132	130	1.6	195	197	—1.0	240	240	0
	Compression	II	196	200	— 2.0	252	255	—1.1	312	310	0.7
	Expansion	III	—123	—127	— 3.2	—195	—197	—1.0	—250	—247	1.2
	Expansion	IV	—180	—185	— 2.8	—254	—255	+0.4	—281	—280	0.4
SO_2	Compression	I	246	220	11.8	276	260	6.2	324	320	1.2
	Compression	II	186	110	9.4	252	246	2.5	328	300	9.3
	Expansion	III	—218	—200	9.0	—272	—260	4.6	—290	—280	3.6
	Expansion	IV	—182	—176	3.5	—258	—246	4.9	—313	—306	2.3
CH_4	Compression	I	116	110	5.5	149	150	—0.6	188	190	—1.1
	Compression	II	95	90	5.6	127	127	0	157	150	4.6
	Expansion	III	—111	—110	0.9	—150	—150	0	—176	—180	—2.2
	Expansion	IV	— 84	— 87	— 3.4	—127	—127	0	—156	—157	—0.6
C_2H_4	Compression	I	114	120	— 5.0	126	134	—6.0	152	160	—5.0
	Compression	II	144	140	2.9	187	190	—1.6	233	240	—2.9
	Expansion	III	—111	—114	— 2.7	—128	—134	—4.6	—146	—154	—5.2
	Expansion	IV	—129	—130	— 0.8	—188	—190	—1.1	—207	—210	—1.4
C_2H_6	Compression	I	185	180	2.8	206	209	—1.4	231	230	0.5
	Compression	II	124	120	3.4	158	157	0.6	188	190	—1.0
	Expansion	III	—161	—150	1.3	—207	—209	—1.0	—241	—249	—3.2
	Expansion	IV	—118	—117	0.8	—158	—157	+0.6	—209	—207	1.0
CH_3Cl	Compression	I	97	99	— 2.0	122	126	—3.2	172	169	1.8
	Compression	II	182	181	0.6	253	255	—0.8	357	351	1.9
	Expansion	III	— 93	— 97	— 4.0	—122	—126	—3.2	—152	—157	—3.2
	Expansion	IV	—180	—184	— 2.2	—254	—255	—0.4	—329	—324	—1.5
CCl_2F_2	Compression	I	97	100	— 3.0	124	130	—4.6	155	160	—3.1
	Compression	II	88	89	— 1.1	115	119	—3.4	146	149	—1.9
	Expansion	III	— 97	—100	— 3.0	—125	—130	—3.8	—150	—160	—6.2
	Expansion	IV	— 77	— 80	— 3.8	—116	—119	—2.5	—145	—150	—3.4
$CHClF_2$	Compression	I	105	110	— 4.6	135	142	—5.0	174	180	—3.3
	Compression	II	122	120	1.7	167	166	0.6	200	200	0
	Expansion	III	—109	—102	4.9	—136	—142	—4.2	—161	—172	—6.4
	Expansion	IV	—107	—116	— 7.8	—167	—166	0.6	—212	—216	—1.8

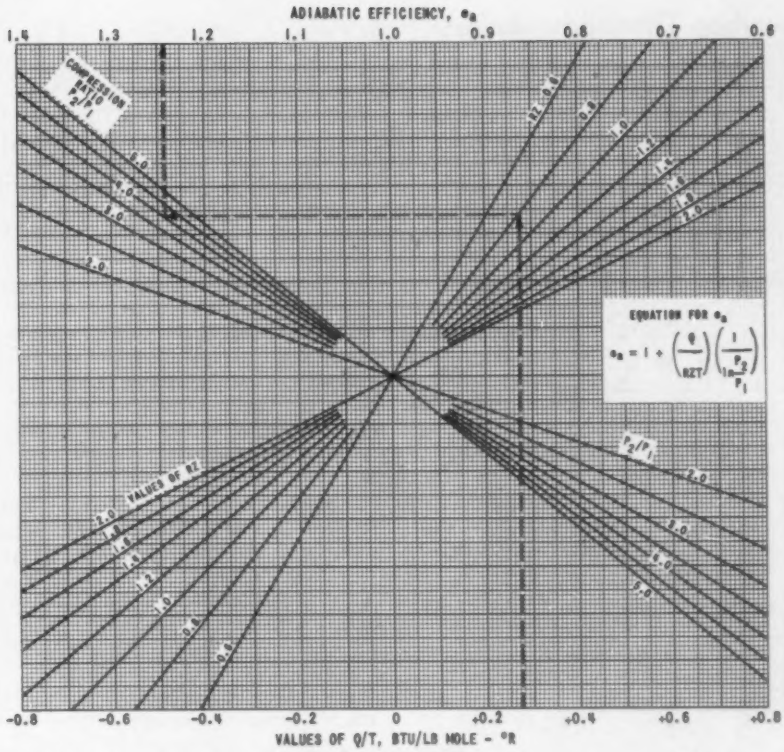

ADIABATIC EFFICIENCY, e_a
1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6
COMPRESSION RATIO P_2/P_1
EQUATION FOR e_a
$e_a = 1 \div \left(\frac{Q}{RZT}\right)\left(\frac{1}{\ln \frac{P_2}{P_1}}\right)$
P_2/P_1
VALUES OF RZ
-0.8 -0.6 -0.4 -0.2 0 +0.2 +0.4 +0.6 +0.8
VALUES OF Q/T, BTU/LB MOLE - °R

FIGURE 8.4—Adiabatic efficiency from entrophy added, gas compressibility constant and compression ratios.

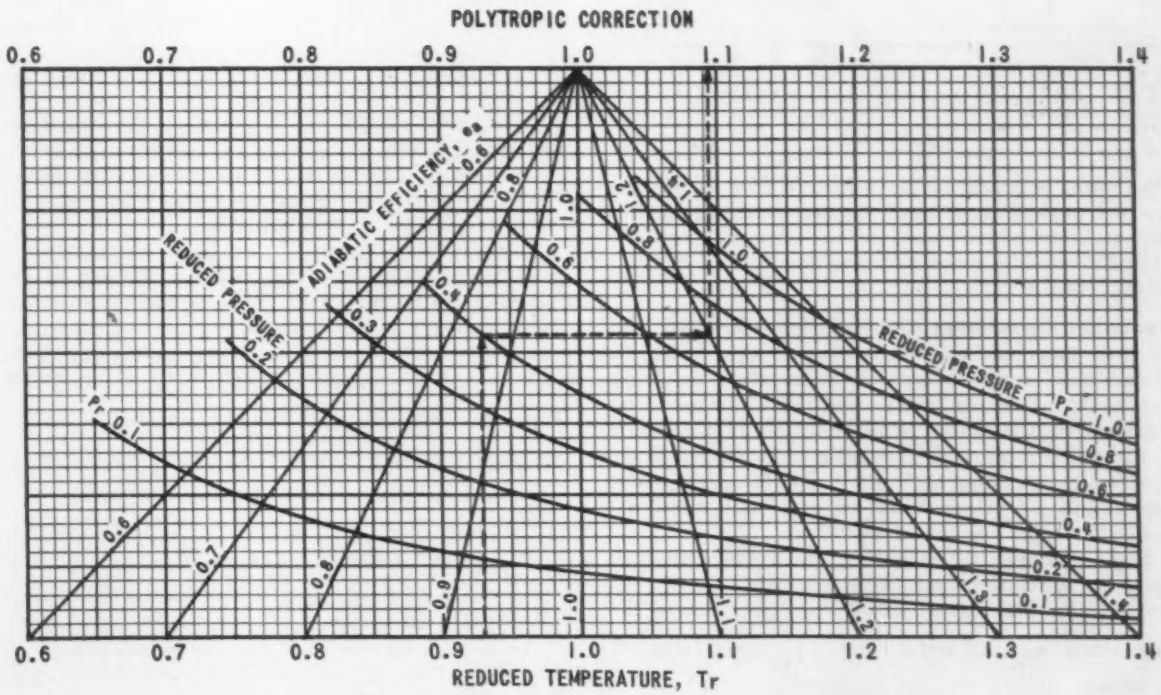


FIGURE 8.5—Polytropic correction for temperature change exponent.

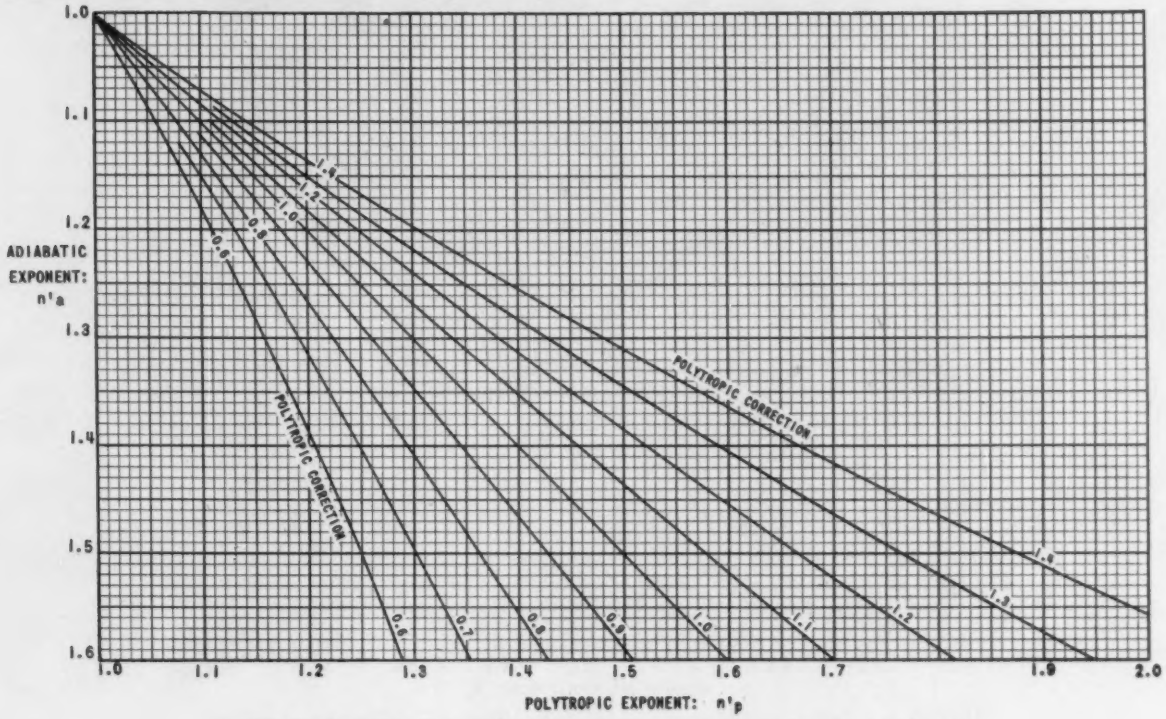


FIGURE 8.6—Polytropic—adiabatic temperature change exponent relationship.

method with values from Mollier charts (or thermodynamic properties tables) are summarized as follows:

	TEMPERATURE CHANGE		
	C	D	E
Total Number of Paths	36	36	36
Average Deviation, Percent	3.5	2.1	2.5
Positive Deviations	19	12	17
Average Positive Deviation, Percent	4..	2.1	2.1
Negative Deviations	17	24	19
Average Negative Deviation, Percent	2.9	2.1	2.8

Agreement is better for the isentropic Path D than for the polytropic Paths C and E. This indicates that the use of arithmetic averages of the terminal properties (C_p, RZ, etc.) is more justifiable for Path D than for Paths C and E.

Exponent Correlation Charts. Figures 8.4, 8.5, and 8.6 were prepared for more convenient exponent calculations. The correction of adiabatic exponents to polytropic exponents, rather than direct calculation of the polytropic exponent, will be shown to be preferable in some cases.

Figure 8.4 is a graphical solution of Equation 8.4 and gives values of e_a from Q/T, P_2/P_1, and RZ values. Average T and RZ values should be used. The dashed example illustrates the use of this chart.

Figure 8.5 gives the ratio on n′ for a polytropic path to n′ for the corresponding adiabatic path from T_r, P_r, and e_a. This plot was prepared from the values of the generalized terms RZ and $RT_r\left(\frac{\partial Z_R}{\partial T_R}\right)_{P_r}$ from Table 7.5, as follows:

Dividing Equation 8.10 by the generalized form of Equation 7.12 gives

$$\text{Polytropic Correction} = \left(\frac{\left(\frac{n'-1}{n'}\right)_p}{\left(\frac{n'-1}{n'}\right)_a}\right) = \left[\frac{RZe_a + RT_r\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}}{RZ + RT_r\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}}\right] \quad (8.18)$$

Point values of RZ and $RT_r\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}$ were read from Table 7.5 at various T_r and P_r values and the "polytropic correction" values were computed at different e_a values. From these calculations, the two-parameter chart Figure 8.5 was prepared. The dashed line example illustrates the use of this chart.

Readings from Figure 8.5 are used to compute the polytropic n′ value from the adiabatic n′ value by the following rearrangement of the first part of Equation 8.18.

$$n'_p = \frac{n'_a}{n'_a - (\text{polytropic correction})\ (n'_a - 1)} \quad (8.19)$$

Figure 8.6 is a graphical solution of Equation 8.16.

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UREA—the Petrochemical to Watch

Here's a triple-threat petrochemical with a dynamic future for fertilizer, animal feeds, and synthetic resins.

Lewis F. Hatch
The University of Texas, Austin

Urea (carbamide, $H_2N-\overset{\overset{O}{\|}}{C}-NH_2$) is a white, odorless, crystalline solid with a cool saline taste. But it is much more than that. It is one of the fastest growing petrochemicals with a 270 percent production increase in eight years (Figure 1). It also has the distinction of being the first synthetic organic chemical. The preparation of urea from ammonium cyanate by Wöhler in 1828 is regarded as the first synthesis of an organic compound from an inorganic compound.

$$NH_4OCN \rightarrow H_2N-\overset{\overset{O}{\|}}{C}-NH_2$$

This made Wöhler both the father of organic chemistry and the first person to produce urea without the use of a kidney. The kidney still out produces the petrochemical industry 4 to 1.

The current growth of urea is richly deserved. It is readily produced from inexpensive raw materials

$$2NH_3 + CO_2 \rightarrow H_2N-\overset{\overset{O}{\|}}{C}-NH_2 + H_2O$$

and it makes the grass green. All of civilization can be equated to two blades of grass — one for food and the other for reproduction. Fortunately, urea is not entirely dependent upon that fickle mistress, agriculture. Urea is also used as an animal feed, to produce resins and for many other industrial applications (Figure 2). Nine companies are producing urea and several others are seriously considering entry into the field.

PRODUCTION

A number of processes are available for the production of urea from ammonia and carbon dioxide. Four of these processes (Chemical Construction Corp., Foster Wheeler Corp., Montecatini and Vulcan-Cincinnati, Inc. [Inventa] are given in the November, 1957, Petrochemical Issue of the PETROLEUM REFINER. Figure 3 illustrates a typical process for the production of both technical and prilled urea.

The chemistry of all the present commercial routes to urea is identical.

$$2NH_3 + CO_2 \rightleftarrows \underset{\text{Ammonium carbamate}}{H_2N-\overset{\overset{O}{\|}}{C}-ONH_4}$$

$$H_2N-\overset{\overset{O}{\|}}{C}-ONH_4 \rightleftharpoons H_2N-\overset{\overset{O}{\|}}{C}-NH_2 + H_2O$$

The formation of ammonium carbamate is an exothermal reaction usually carried out in the temperature range of 175 to 210 C. and under about 200 atmospheres pressure. The reaction must take place in the liquid phase, and the reaction mixture is highly corrosive.

About half of the ammonium carbamate is in equilibrium

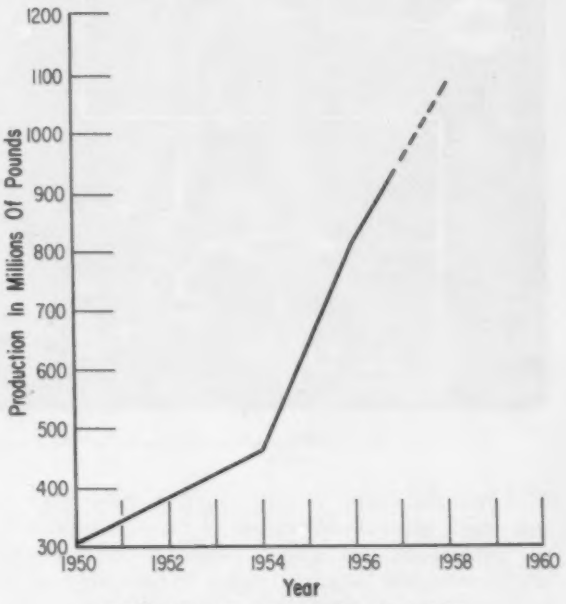

FIGURE 1—Urea production since 1950.

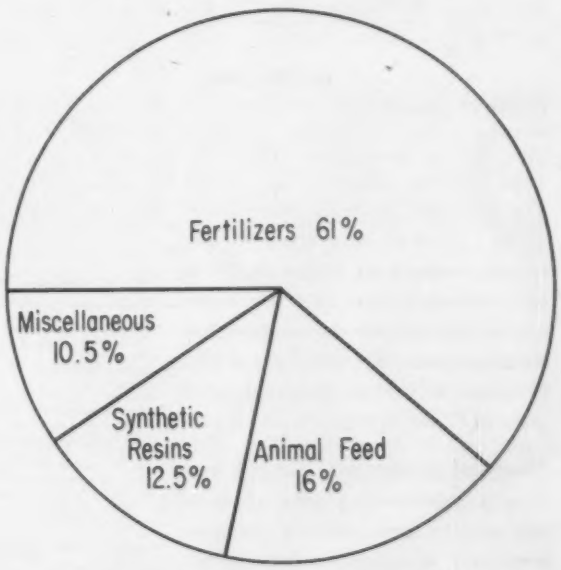

FIGURE 2—Estimated 1958 urea end-use pattern.

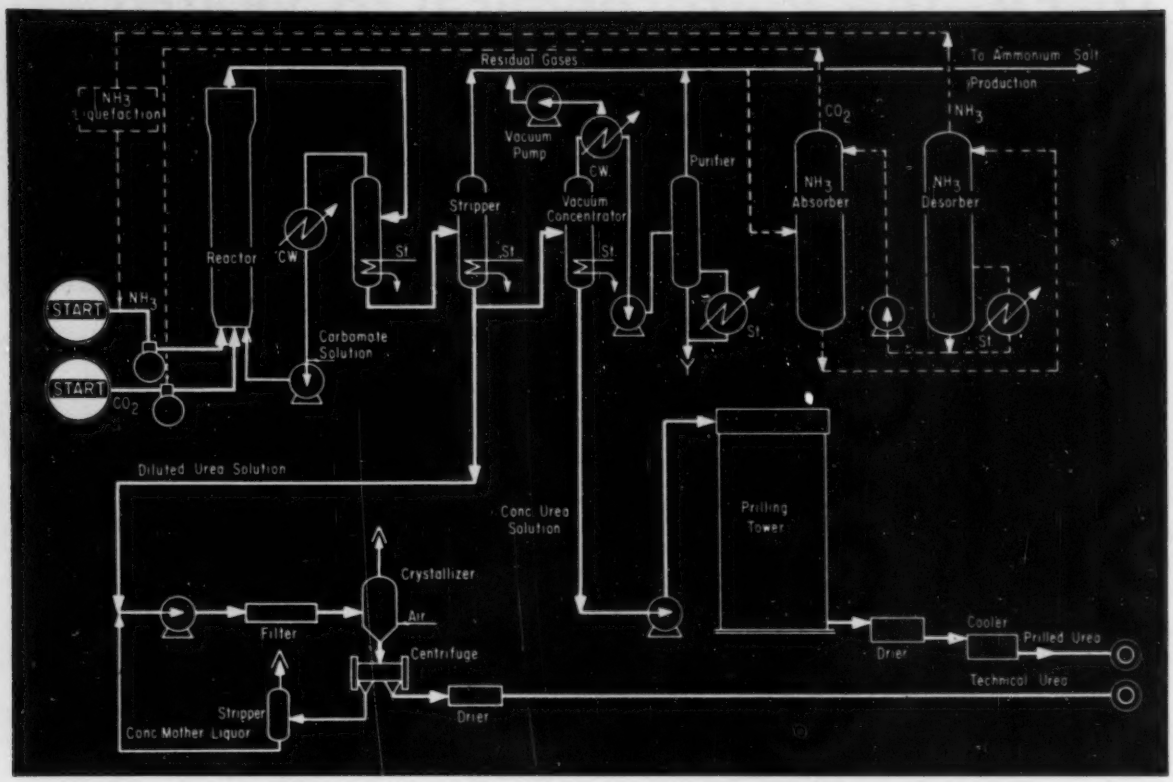

FIGURE 3—A typical process for the production of technical and prilled urea (Montecatini).

with urea and water. A reduction in pressure in a "decomposer" causes decomposition of the carbamate without affecting the urea. The ammonia and carbon dioxide are removed and may be recycled to the system or the ammonia may be converted to a derivative such as ammonium sulfate. The urea is obtained by concentration, filtration and crystallization. Prilled urea is gaining in popularity.

PROPERTIES

Physical properties. Probably no chemical sold in tonnage quantities has the purity of the "high purity" urea now on the market. This high degree of purity assures uniform properties and processing characteristics. The principal physical properties of urea are given in Table 1. Urea sublimes under vacuum at temperatures just below and up to its melting point. It is somewhat hygroscopic and absorbs moisture from the atmosphere. The solubility of urea in water at various temperatures is given in Figure 4.

Chemical properties. Table 2 contains a summary of the chemical reactions of urea. One of the most important of these reactions is hydrolysis.

$$H_2N-\overset{O}{\overset{\|}{C}}-NH_2 + H_2O \rightarrow 2NH_3 + CO_2$$

The hydrolysis reaction is very slow in neutral solutions and in the absence of microorganisms. Acids, bases and high temperatures increase the rate and urea is also hydrolyzed by the enzyme **urease.** No hydrolysis inhibitors are known.

The chemical properties and some of the physical properties of urea can be explained on the assumption that it is a resonance hybrid of two zwitter ions and the carbamide structure.

$$\overset{+}{H_2N}=\overset{O^-}{\overset{|}{C}}-NH_2 \longleftrightarrow H_2N-\overset{O}{\overset{\|}{C}}-NH_2 \longleftrightarrow H_2N-\overset{O^-}{\overset{|}{C}}=\overset{+}{NH_2}$$

TABLE 1
Physical Properties of Urea

Molecular weight	60.06
Boiling point, C	Decomposes
Melting point C	132.7 (decomposition)
Refractive index, n_D^{20}	1.484 and 1.602
Density, d_4^{20}	1.335
Heat of fusion, cal./g.	−5.78 to −6.00
Heat of combustion, cal./g.	2531
Resonance energy, kcal.	41
Free energy of formation at 25° C., cal./mole (solid)	−47,120
Specific heat at 20° C., cal./(g.)(°C.)	0.320
Heat of solution in water, cal./g.	−57.8
Solubility (g./100 g. solvent):	
Water (see Figure 4)	
Methanol	27.7
Ethanol	7.2
n-Propyl alcohol	3.6
Isobutyl alcohol	2.3
Isoamyl alcohol	1.6

TABLE 2
Chemical Properties of Urea

REAGENT	PRODUCT
Strong acids	Salts
Sulfuric acid/nitric acid	Nitroures
Sulfuric acid/sulfur trioxide	Sulfamic acid
Alkali metals	Substitution compounds (e.g. sodium urea)
Hypochlorites	Hydrazine
Hydroxides or carbonates (on heating)	Cyanates
Hydrogen peroxide	Urea peroxide
Alcohols (elevated temperatures)	Carbamates
Aldehydes	Alkylol derivatives of bis ureas
Organic acids (on heating)	Amides
Anhydrides	Acyl ureas
Esters	Acyl ureas
Amines	Alkyl or aryl derivatives
Hydrolysis	Ammonia and carbon dioxide
Decomposition	Biuret, cyanuric acid, etc

Urea and its aqueous solutions are noncorrosive to steel, nickel, aluminum and stainless steels at ordinary temperatures. Conditions favoring hydrolysis may present corrosion problems.

USES

The four major use categories for urea — fertilizers, animal feeds, synthetic resins, and miscellaneous industrial applications — are indicated in Figure 2. While agriculture takes the bulk of urea production, other uses of urea are many and increasing in both number and quantity of urea consumed. The assured future of urea is in fertilizers but the inevitable fluctuations of agricultural demands will be cushioned by the many other uses of urea.

Fertilizers. The use of urea as a fertilizer has more than doubled since 1954. This remarkable acceptance of urea is based on its good leach resistance in the soil and the fact that it leaves no soil residues. It is also a highly concentrated source of available nitrogen, being exceeded only by anhydrous ammonia among the commercial fertilizers (Table 3). An added feature is its noncorrosive character toward application equipment.

The rapidly expanding use of urea as a fertilizer is closely related to the recent development of solution application of fertilizers. Urea is second to ammonia in this type of application and the fertilizer use of urea is expected to grow with the growth of solution techniques. This method permits appreciable flexibility. For example, some of the newer experimental solutions contain diammonium phosphate (for pasture lands) and urea-formaldehyde mixtures. The latter mixtures, with an excess of formaldehyde, may be valuable as soil fumigants.

Animal feeds. Urea permits the use of cheaper, low protein carbohydrate feeds for ruminant animals — especially cattle. The urea supplies the nitrogen needed for the biochemical synthesis of proteins by the microorganisms of the rumen.

Urea in animal feeds is in direct competition with soybean and cottonseed meals and these sources of nitrogen will continue to dominate the nitrogen feed supplement field because of their cost advantage and availability. Urea also has the disadvantage of toxicity when used in large amounts and at present its use is limited to one-third of the protein available in a mixed feed, the rest is made up of oilseed meals.

Synthetic resins. The largest industrial use of urea is in the production of three types of thermosetting resins: urea-formaldehyde, urea-furfural-formaldehyde and urea-resorcinol. Together they are expected to account for at least 150 million pounds of urea in 1958. The figure was only 94 million pounds in 1950. The urea-formaldehyde resins represent nearly all of this urea use (Figure 5). The most important end-use outlets are in molding (radio and television cabinets), in paper and fabric treatment and as adhesives for bonding of wood veneer into plywood (Table 4).

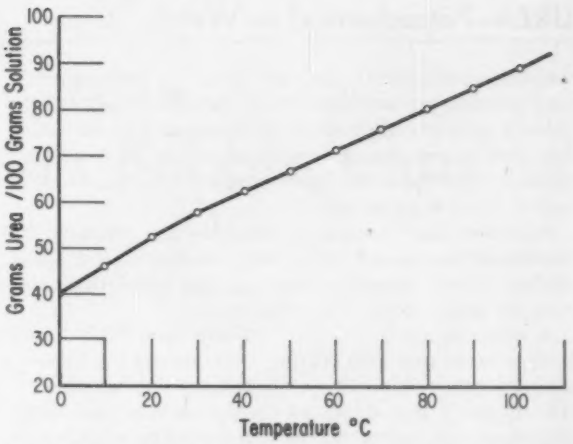

FIGURE 4—Solubility of urea in water as a function of temperature.

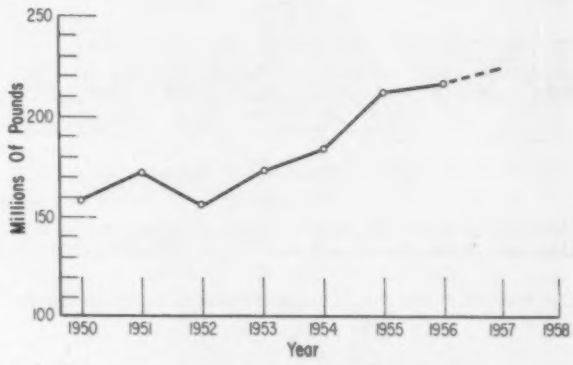

FIGURE 5—Production of urea-formaldehyde type resins (does not include mixed urea-melamine resins).

The urea-formaldehyde resins are nearly colorless and may be pigmented to almost any color, including pastel shades. They are available as molding powders, laminating resins and as resins for coating use. They improve crush and crease resistance in textiles and impart wet strength to paper and paper coatings. Their molding and laminating characteristics are similar to those of the phenolics but the molded products have poorer dimensional stability than the phenolics and they are more temperature and water sensitive.

The production of urea-formaldehyde molding resins is a comparatively simple operation consisting of condensation under ordinary temperatures and pressures with the addition of a catalyst. Paper pulp or other filler is added to the resulting solution and the mixture is hot air dried and ground. Coloring pigments and a

TABLE 3
Ammonia Based Fertilizers

NAME	Formula	Percent Nitrogen
Ammonium sulfate	$(NH_4)_2SO_4$	21
Ammonium nitrate	NH_4NO_3	35
Sodium nitrate	$NaNO_3$	16.5
Calcium nitrate	$Ca(NO_3)_2$	17
Ammonium chloride	NH_4Cl	26
Ammonium phosphate	$(NH_4)_2PO_4$	28
Urea	$H_2N\text{-}\overset{\overset{O}{\|}}{C}\text{-}NH_2$	46
Ammonia	NH_3	82

TABLE 4
Recent Use Pattern of Urea and Melamine Resins (73 Percent Urea Resins)

	Percent
Textile-treating and textile-coating resins	15
Paper-treating and paper-coating resins	7
Bonding and Adhesive Resins for:	
Plywood	30
All other bonding and adhesive uses including laminating	9
Protective coating resins, straight and modified	12
Resins for all other uses, including molding*	27

* The single largest use for melamine resins.

molding accelerator are then added and the resin is given a final grinding operation in a brine cooled ball mill. If light colored products are desired, it is necessary to use stainless steel or aluminum equipment. The dark colored urea-formaldehyde molding powders are the least expensive of all molding plastics.

Adhesives and laminating solutions are produced by condensation followed by vacuum concentration or spray drying. Small amounts of acid or acid generating catalysts are added to cause the resin to set.

A different mole ratio of urea and formaldehyde are used to make resins for coating solutions and the condensation product is alkylated by boiling with an alcohol. The water is first displaced by the alcohol then, after alkylation, the excess alcohol is replaced by a hydrocarbon solvent.

The urea-formaldehyde resins appear to be relatively

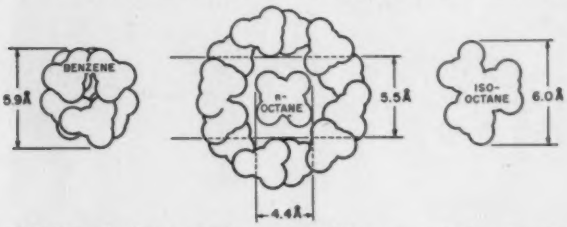

FIGURE 6—Urea selectively crystallizes around the organic molecule. [From Petroleum Refiner, 36(5), 217 (May, 1957)].

low molecular weight. The proportion of methylene linkages $(-HNCH_2NHC(=O)-)$ and methylene-ether linkages $(-HNCH_2OCH_2NHC(=O)-)$ in the polymer formed under the neutral or weakly acid commercial conditions of condensation is not known. Association effects seem important in determining the characteristics of these resins and distinguishes them from other condensation products. The chemistry of the urea-formaldehyde resins is being actively investigated.

Other applications. Urea has a number of applications some of which are dependent upon physical properties and others upon chemical reactions.

Urea is used as an ingredient in softeners for many products based on cellulose such as glassine and other papers, cellophane, cellulose sponge and wood. It is used to retard end-checking of boards during drying and it facilitates bending of the board. The addition of urea to casein, animal glue, gelatin and starch sizes and adhesives for paper products results in a reduction of viscosity and permits the use of higher concentrations of active material.

Of more direct interest to the petroleum industry is the use of urea in petroleum treating to separate straight-chain hydrocarbons from other types through *extractive crystallization*. The separation is effected by the formation of crystalline channel inclusion complexes between urea and a hydrocarbon with a sufficiently long normal carbon atom chain (Figure 6). A normal carbon atom chain of between 10 and 12 carbon atoms is the borderline for the formation of these insoluble complexes at 25 C.[1] The composition of the complexes of normal alkanes is given by

$$m = 0.653n + 1.51$$

or

$$m = 0.6925n + 1.49$$

where

m = number of urea molecules
n = number of carbon atoms.[1]

Both formulas give essentially the same information. The mechanism of urea complex formation is discussed in the PETROLEUM REFINER's symposium on "Urea Complexes" (April, 1955).

The use of this technique by the petroleum industry is in the production of low-cold-test oils from waxy crudes. The first U. S. plant using this process has been described by Rogers, Brown, Diekman and Kerns.[2] The plant was designed to dewax a nominal 1000 barrel per stream day of light lubricating stocks of 50 to 220 SSU viscosity to pour points of —55 F. (50-viscosity oil) to —25 F. (220-viscosity oil). A similar German plant has been described by Hoppe and Franz.[3]

It has been reported that the process holds promise for jet fuel refining.

The **chemical utilization** of urea includes the preparation of bartituric acid, caffein, ethylurea, hydrazine, melamine, guanidine, urea peroxide and sulfamic acid. The amount of urea used for these purposes is difficult to estimate but approximately 120 million pounds is expected to be used in 1958.

One of the largest chemical uses is in the production of sulfamic acid.

$$H_2N-C(=O)-NH_2 + SO_3 + H_2SO_4 \rightarrow 2H_2NSO_3H + CO_2$$

Sulfamic acid and its salts are used as softening agents for paper and textiles, flame retardents, weed and brush killers, metal cleaners and electroplating salts.

Medicinal and **miscellaneous** uses are extremely varied. Urea is used medicinally as a diuretic, a synergist for certain sulfa drugs and in veterinary medicine, with sulfur, to control coccociosis in poultry. Cosmetic applications include use in some deodorants to minimize tendering of fabrics by aluminum sulfate and in skin creams and lotions to improve feel. Dyes and pigments may use four million pounds of urea in 1958 while synthetic detergents, explosives (to prevent accidental detonation) and beer and liquor fermentation will require substantial quantities.

THE FUTURE

All of these uses and many others will supplement the demands for urea by the three major outlets — fertilizers, animal feeds and synthetic resins. Fertilizer uses will grow with the wider acceptance of nitrogen solutions and animal feeds will continue strong, especially if the price of urea drops with increased urea capacity. Urea-formaldehyde resins show a less impressive growth curve but they have the advantage of use stability unaffected by the season or the weather — climatic and political. The many miscellaneous industrial applications also have a stabilizing effect on urea consumption. The over-all outlook is bright for urea.

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[1] Schiessler, R. W. and Neiswender, D. D., *J. Org. Chem.*, 22, 697 (1957).
[2] Rogers, T. H., Brown, J. S., Diekman, Robert, and Kerns, G. D., PETROLEUM REFINER, 36(5), 217 (May, 1957).
[3] Hoppe, I. A. and Franz, H. PETROLEUM REFINER, 36(5), 221 (May, 1957).

More data to help you figure . . .

Pressure Drop Through Bubble Caps

To get consistently good results from pressure drop calculations, try this approach which is based on the fundamentals of fluid flow.

H. T. Welch
Union Carbide Corporation, New York City

AN ACCURATE PREDICTION of pressure drop is essential to the design of a bubble cap tray. Among the factors which are directly dependent on this prediction are reboiler operating pressure and temperature, the liquid height in the downcomer, and the vapor distribution ratio-criterion of a stable tray.

The only methods of calculation which can be relied on to give consistently good results are those which have their basis in the fundamentals of fluid flow. With these methods reasonably accurate calculations can be made regardless of cap and riser configuration.

As the vapor passes from one area to another within the cap it is subject to expansion or contraction depending on the relative size of the areas involved. The decrease in pressure resulting from these losses as well as from the changes of direction, orifice effects, etc. have been determined and are included in equations which apply to the various parts of the cap-riser assembly.

The total tray pressure drop is made up of the pressure drop through the dry tray plus the pressure drop caused by the liquid on the tray. The dry tray pressure drop is subdivided into its component parts as follows:

- Riser pressure drop:

$$h_u = 0.002986\, K_u\, \rho_v\, (V/A_u)^2 \qquad (1)$$

- Reversal pressure drop:

$$h_r = 0.002986\, (K_{r_1} + K_{r_2} + K_{r_3})\, \rho_v\, (V/A_r)^2 \qquad (2)$$

- Slot pressure drop:

$$h_s = 0.002986\, (K_{s_1} + K_{s_2})\, \rho_v\, (V/A_s)^2 \qquad (3)$$

The constants for the above equations are dependent on the ratio of the areas involved and can readily be taken from prepared charts.

The pressure drop caused by the liquid on the tray is the product of the aeration factor and the flowing submergence. Thus the total pressure drop may be expressed as:

$$h_t = h_u + h_r + h_s + \psi S_t \qquad (4)$$

The dry tray pressure drop equations were developed from consideration of fluid flow principles beginning with Bernoulli's equation. This equation was applied to the riser, reversal, annular space, and slots. The friction losses were estimated wherever possible from an analysis of the flow involved, for example: contraction, expansion, orifice effect, etc.

A new correlation is presented for the aeration factor. This is based on data obtained by the author in conjunction with Dr. William Smolin[6] on a one tray, water-air system set up in the laboratories of the Polytechnic Institute of Brooklyn. This correlation may be represented by the following equation:

$$\psi = 0.66 + \frac{0.64}{S_t} - \frac{0.135}{S_t^{0.8}}\, F^1 \qquad (5)$$

The column factor F, used in the above equation is the product of the superficial linear vapor velocity through the column and the square root of the vapor density.

APPLICATION OF METHOD TO DESIGN

In order to provide a convenient and rapid method of calculation, the equations for the pressure drop through the various parts of the cap have been put into simplified form. The simplification consists of a grouping of terms to form a factor which is a function of a ratio of the areas involved. The factor can then be taken from a prepared plot after calculating only the area ratio. These plots are shown as Figures 1 through 5. The remaining factor K_{r_1} is determined from an empirical correlation and can be evaluated from the following equation:

$$K_{r_1} = \frac{100}{\frac{Amin}{Amax}\left(1 + \frac{A_s}{A_u}\right) + 1.061} - 29.03 \qquad (6)$$

Before calculating the slot pressure drop (Equation 3) it is necessary to determine the area of the slots which is actually open to vapor flow. This can be determined from the following equation:

$$A_s = 0.192\, (wnNV^2\, \rho_v/\rho_l)^{1/3} \qquad (7)$$

In order to expedite the calculation, a prepared form may be used on which may be entered the variable figures. A suggested version of such a form is shown. In this case, the sample calculation shown is that of a 24-feet diameter tray of a vacuum column of a crude frac-

tionation unit.[3] The calculated pressure drop is 1.60 inches of water which provides a good check with actual experience.

DEVELOPMENT OF EQUATIONS

Tray pressure drop equations have been developed from consideration of fluid flow principles beginning with Bernoulli's equation:

$$-\sum F - W = \Delta Z + \frac{\Delta u^2}{2g} + \int_1^2 VdP \qquad (8)$$

Since the work, W, and the change in height, Z, can be neglected, and assuming the vapor density to be constant, we have:

$$\frac{P_1 - P_2}{\rho_v} = \frac{U_2^2 - U_1^2}{2g} + \sum F \qquad (9)$$

where F refers to the friction losses. This equation was applied to the component parts of the cap. The friction losses were estimated wherever possible from an analysis of the flow involved, for example: contraction, expansion, change of direction, etc.

Riser Pressure Drop. The friction losses in the riser are considered to be made up of an entrance loss plus a skin friction loss through the straight section of the riser.

For the entrance loss the equation which applies to a sharp edged entrance will be used:[4]

$$\Delta H = K \frac{U_2^2}{2g}$$

where: ΔH = feet of fluid pressure drop

K = a constant whose value varies with the ratio of areas before and after the contraction

The skin friction loss was evaluated and found to be a negligible portion of the total riser pressure drop. Therefore the total riser pressure drop is:

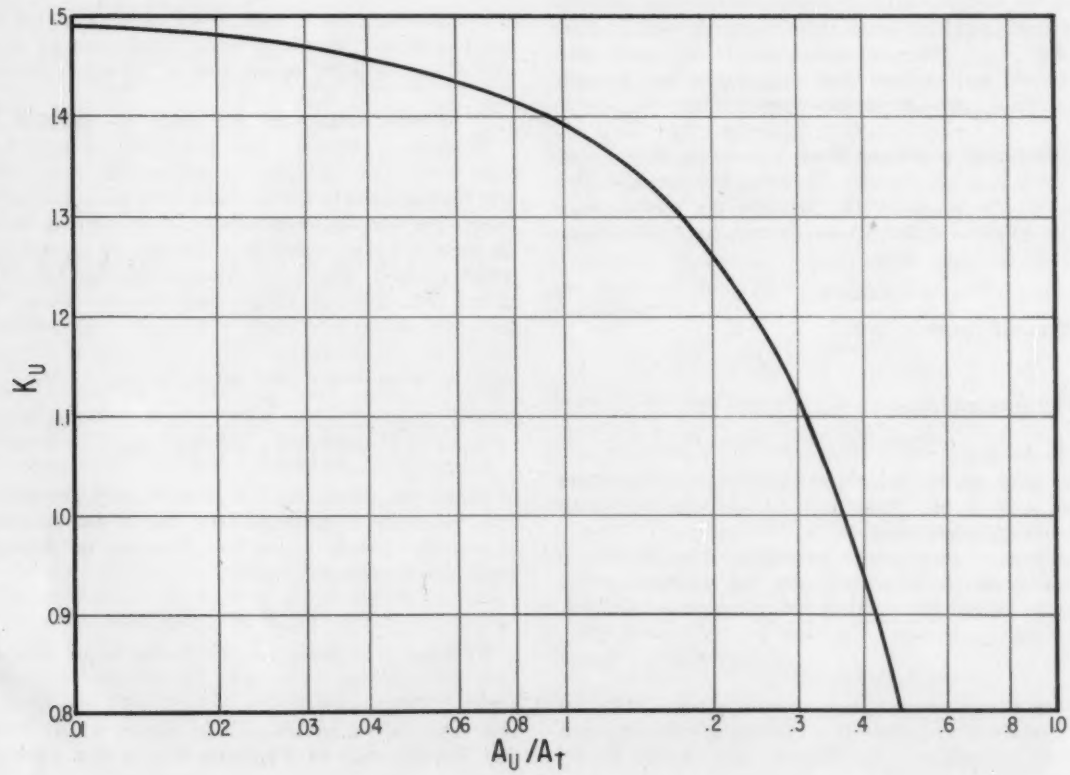
$$\Delta H = \frac{\rho_v}{2g}\left\{\left[\left(\frac{V}{A_u}\right)^2 - \left(\frac{V}{A_t}\right)^2\right] + 0.4\left(1.25 - \frac{A_u}{A_t}\right)\left(\frac{V}{A_u}\right)^2\right\} \qquad (10)$$

Expressed in inches of water, this becomes:

$$h_u = 0.002986\,\rho_v\left(\frac{V}{A_u}\right)^2\left\{\left[1 - \left(\frac{A_u}{A_t}\right)^2\right] + 0.4\left(1.25 - \frac{A_u}{A_t}\right)\right\} \qquad (11)$$

or

FIGURE 1—The pressure drop factor for the riser is related to an area ratio by the following equations: $K_u = 1.5 - A_u A_t - (A_u/A_t)^2$.



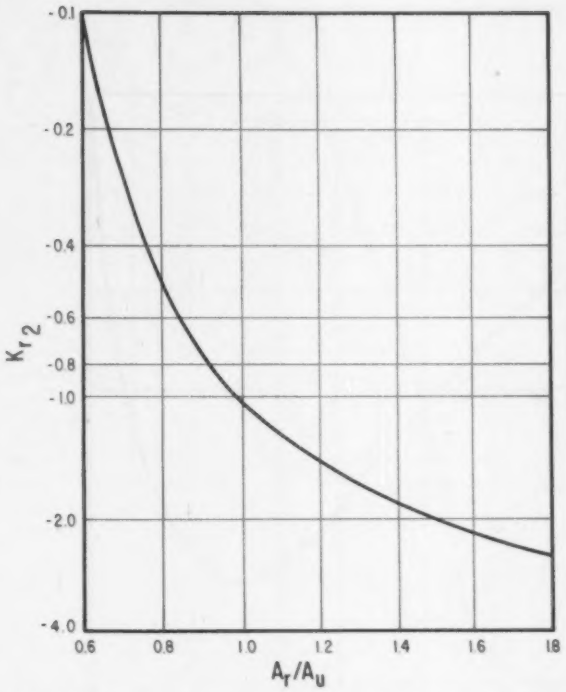


FIGURE 2—A factor is needed to account for the vapor passing from the riser area to the reversal area.

FIGURE 3—(below) Another factor is needed to account for the vapor passing from the reversal area.

$$h_u = 0.002986\,\rho_v \left(\frac{V}{A_u}\right)^2 \left[\,1.5 - 0.4\,\frac{A_u}{A_t} - \left(\frac{A_u}{A_t}\right)^2\,\right] \quad (12)$$

The factor within the brackets of Equation 12 is a function of the ratio A_u/A_t only. This factor, called K_u, is plotted in Figure 1.

Reversal and Annular Pressure Drop—For reasons of simplification, the pressure drop experienced by the vapor as it passes through the reversal area and the annular area will be combined and will be referred to as the reversal pressure drop.

In the reversal pressure drop we consider the vapor flowing from the riser area into the reversal area and then from the reversal area into the annular area. Thus two velocity heads are involved.

The friction losses involved are caused by the following flow changes:

F_{r_1}—180 degree change of direction

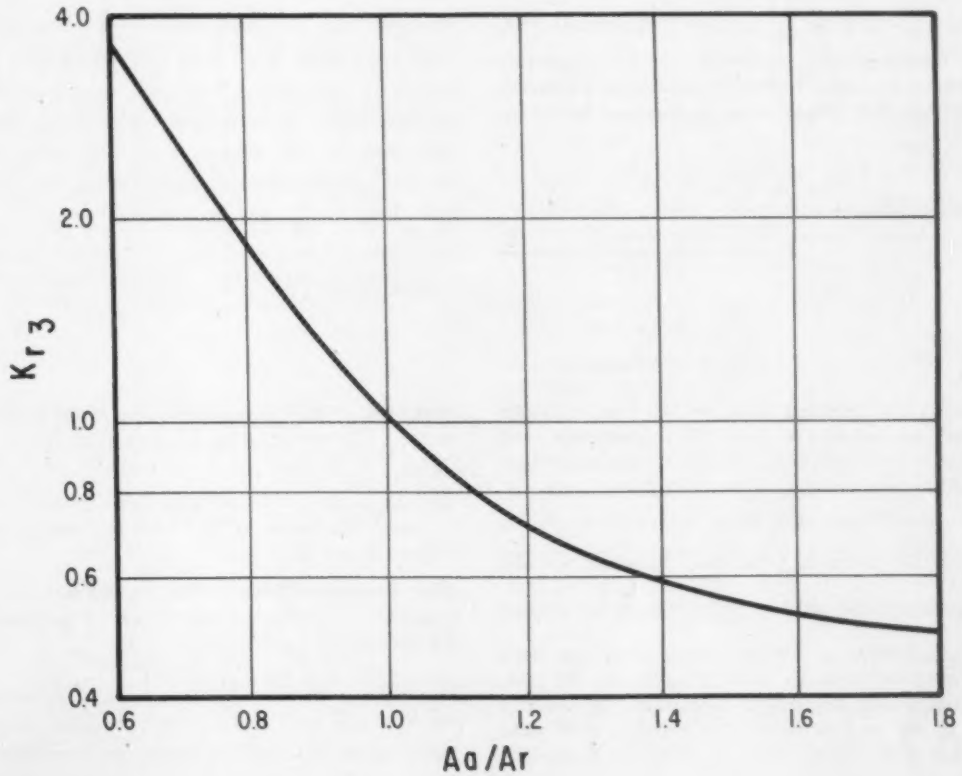
F_{r_2}—Expansion or contraction as the vapor passes from the riser area to the reversal area

F_{r_3}—Expansion or contraction from reversal area to annular area.

Bernoulli's equation, incuding the above factors becomes:

$$\Delta H = \frac{\rho_v}{2g}\left\{\left[\left(\frac{V}{A_r}\right)^2 - \left(\frac{V}{A_a}\right)^2\right] + \left[\left(\frac{V}{A_a}\right)^2 - \left(\frac{V}{A_r}\right)^2\right]\right\} + F_{r_1} + F_{r_2} + F_{r_3} \quad (13)$$

The last two friction losses may be evaluated from the



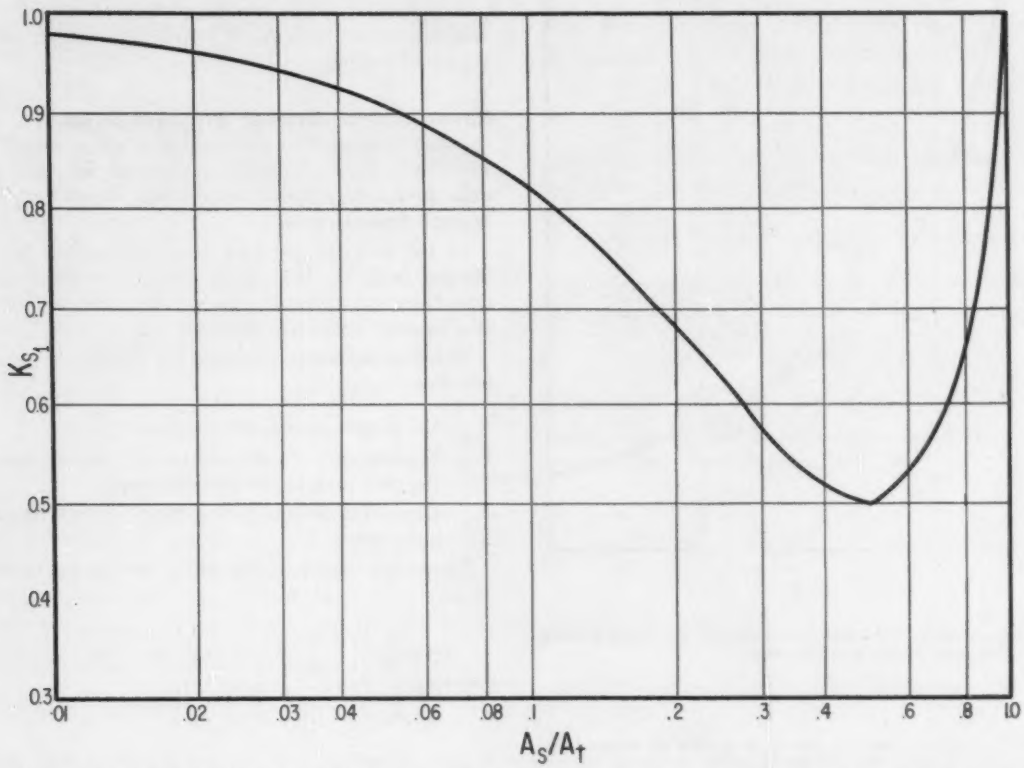


FIGURE 4—The slot pressure drop factor depends on the following equations: $K_{s_1} = 2\,(A_s/A_t)^2 - 2\,(A_s/A_t) + 1.0$.

commonly used equations for contraction and expansion losses and may be found in Perry's *Chemical Engineer's Handbook*, page 388. These can be generalized by the expressions:

$$F_{r_2} = k_{r_2}\,\rho_v\,(V/A_r)^2$$
$$F_{r_3} = k_{r_3}\,\rho_v\,(V/A_r)^2$$

where k_{r_2} varies with A_r/A_u and k_{r_3} varies with A_u/A_s

The friction loss resulting from the 180-degree change of direction can not be estimated by a commonly used equation or set of equations. However, assuming that its form will be similar to the others, we have:

$$F_{r_1} = K_{r_1}\,\rho_v\,(V/A_r)^2$$

The value of the factor K_{r_1}, has been found empirically to be a function of the term $\left[\frac{A_{min}}{A_{max}}\left(1 + \frac{A_s}{A_u}\right)\right]$ where A_{min} and A_{max} refer to the minimum and maximum annuar or reversal area. In order to arrive at the relationship from which K_{r_1} might be determined, the dry tray data of the author were used together with data These values of K_{r_1} were found to correlate in accordance with empirical Equation (6). If we let:

$$K_{r_2} = k_{r_2} - (A_r/A_u)^2$$
$$\text{and} \quad K_{r_3} = (1 + k_{r_3})\,(A_r/A_u)^2$$

then Equation (14) can be further simplified to Equation (2) and the values of K_{r_2} and K_{r_3} can be taken from Figures 2 and 3.

from the literature[1,2,5]. The reversal pressure drops were found by subtracting from the experimental dry tray pressure drop, the calculated values of the riser pressure drop and the slot pressure drop. The value of K_{r_1} were then calculated from the equation for the reversal pressure drop which may be expressed as:

$$h_r = 0.002986\,\rho_v\,(V/A_r)^2\left[K_{r_1} + k_{r_2} + (1 + k_{r_3})\left(\frac{A_u}{A_s}\right)^2 - \left(\frac{A_r}{A_u}\right)^2\right] \tag{14}$$

Slot Pressure Drop—The application of Bernoulli's equation to the flow of vapor through the slots results in the following:

$$\Delta H = \frac{\rho_v}{2g}\left\{\left[(V/A_t)^2 - (V/A_s)^2\right] + \left[(V/A_s)^2 - (V/A_u)^2\right]\right\} + F_{s_1} + F_{s_2} + F_{s_3} \tag{15}$$

Here again two velocity heads are involved: (1) from

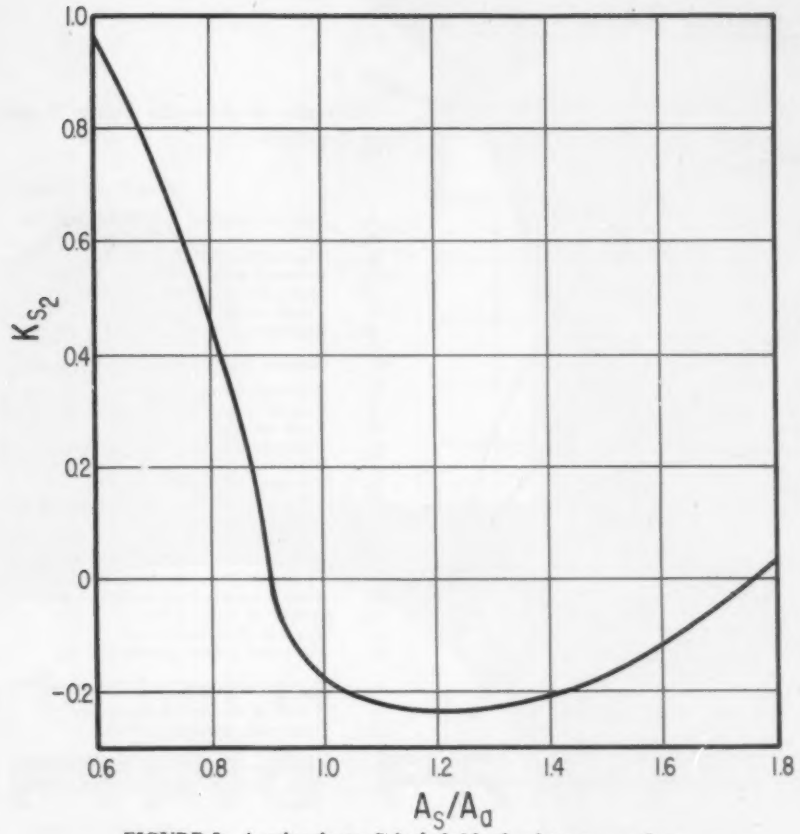


FIGURE 5—Another factor is included in the slot pressure drop.

the annular area to the slot area and (2) from the slot area to the open tower area. The three friction factors involved are:

F_{s_1}—The orifice effect or expansion loss as the vapor passes from A_a to A_s

F_{s_2}—90 degree change of direction

F_{s_3}—Expansion loss as vapor leaves the slots

Combining these factors to arrive at the equation for the slot pressure drop, we have two cases, depending on whether A_s is smaller than A_a (orifice effect applies) or A_s is larger than A_a (expansion effect applies)

Case I ($A_s < A_a$):

$$h_s = 0.002986\,\rho_v\left(\frac{V}{A_s}\right)^2 \left\{\left[\left(\frac{A_s}{A_t}\right)^2 - \left(\frac{A_s}{A_a}\right)^2\right] + 1.62\left[1-\left(\frac{A_s}{A_a}\right)^2\right] + 0.74\left(\frac{A_s}{A_a}\right)^2 + \left(\frac{A_s}{A_t}-1\right)^2\right\} \quad (16a)$$

Case II ($A_s > A_a$):

$$h_s = 0.002986\,\rho_v\left(\frac{V}{A_s}\right)^2 \left\{\left(\frac{A_s}{A_t}\right)^2 - 0.26\left(\frac{A_s}{A_a}\right)^2 + \left(\frac{A_s}{A_a}-1\right)^2 + \left(\frac{A_a}{A_t}-1\right)^2\right\} \quad (16b)$$

These equations can be reduced to Equation (3) and the factors K_{s_1} and K_{s_2} can be taken from Figure 4 and 5, respectively.

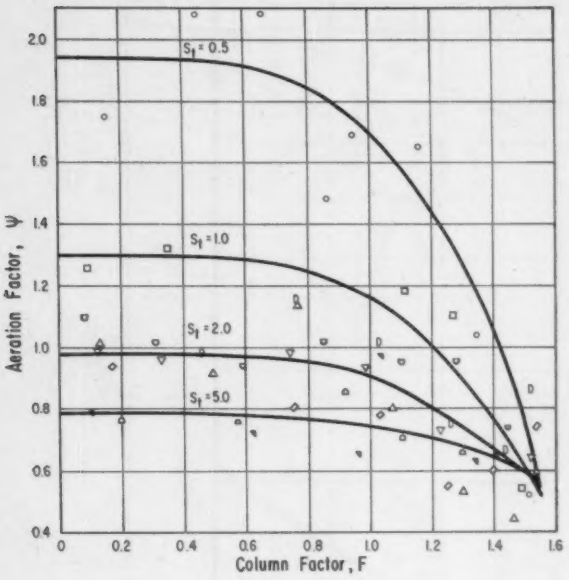
Slot Opening—The Area A_s used in Equation (16) is called the effective slot area. That is, the area which is actually open to vapor flow. At low vapor rates the cap slots may not be fully open and A_s will then be less than the total area of the cap slots. On the other hand, when a skirt clearance is maintained and when the vapor rate is higher than that required to completely open the slots, A_s will be greater than the area of cap slots, for in this case the open skirt area is included in A_s.

Equation (7) is suggested for the calculation of A_s. Developed from the equation of Zenz[7] it has been found to be in agreement with the more cumbersome equations of Cross and Rider.

Aeration Factor—Extensive laboratory data were taken by the author and Dr. William Smolin on an air-water system. The pressure drop due to the liquid on the tray was calculated by subtracting the pressure drop at zero seal from the total experimental pressure drop:

$$h_f = h_t - h_s$$

The aeration factor was then calculated by dividing h_f by the average total submergence S_t. The resulting



S_T	0.48	1.04	1.48	1.98	2.04	2.34	3.04	4.1	4.6
Runs	26-32	46-52	19-25	33-38	53-58	39-45	59-64	123-128	129-134

FIGURE 6—The author obtained data to establish the aeration factor.

correlation is shown in Figure 6 and can be expressed by Equation (5).

SYMBOLS USED

A_a	Area of annulus, square feet per tray
A_{max}	Maximum value of A_a or A_r
A_{min}	Minimum value of A_a or A_r
A_r	Reversal area, square feet per tray
A_s	Slot area, square feet per tray
A_t	Tower cross sectional area open to vapor flow
A_u	Riser area, square feet per tray
F	Column factor equals $\left(\frac{V}{A_t}\right)\sqrt{\rho_v}$
N	Number of caps per tray
V	Rate of total vapor flow, cubic feet per second
d_u	Riser diameter, inches
g	Gravitational constant, feet per second per second
h_d	Dry tray pressure drop, inches of water
h_f	Pressure drop due to liquid on tray
h_o	Tray pressure drop at zero seal, inches of water
h_{ow}	Height of liquid over weir
h_r	Reversal pressure drop, inches of water
h_s	Slot pressure drop, inches of water
h_t	Total tray pressure drop, inches of water
h_u	Riser pressure drop, inches of water
h_w	Height of weir, inches
n	Number of slots per cap
h_2	Static slot submergence, inches
s_t	Flowing submergence, equals $h_{ow} + h_2 + \frac{\Delta}{2}$
w	Width of slot at base, inches
Δ	Hydraulic gradient, inches
ψ	Aeration factor
ρ_l	Liquid density, pounds per cubic feet
ρ_v	Vapor density, pound per cubic feet

ACKNOWLEDGMENT

This report is based on a thesis completed by the author in 1956 toward a master's degree in chemical engineering under the direction of Dr. Ju Chin Chu at the Polytechnic Institute of Brooklyn.

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[6] Smolin, W., D. ChE. Thesis, Poly. Inst. of Brooklyn (1956).
[7] Zenz, F. A., PETROLEUM REFINER, 32, 1, 150 (January, 1953).

Here is a suggested form for calculation . . .

	Sq. Ft.	(Sq. Ft.)$^{(2)}$	
A_u	40.1	1606	V = 3945 CFS
A_r	47.6	2264	ρ_v = .0050lb/CF
A_a	50.5		ρ_l = 48.6
A_s	36.8	1352	w = 0.375
A_t	315		n = 32
			N = 460
			$A_s = 0.192\ (wnNV^2\rho_v/\rho_l)^{1/2}$
A_u/A_t	= 0.1234		$K_u = 1.435 \div A_u^2 = 0.000884$
A_r/A_u	= 1.187		$K_{r_2} = -1.37$
A_a/A_r	= 1.06		$K_{r_2} = 0.90$
$\frac{A_{min}}{A_{max}}\left(1+A_a/A_u\right)$	= 2.178		$K_{r_1} = \frac{1.85}{1.38 \div A_r^2 = 0.00061}$
A_s/A_t	= 0.1168		$K_{s_1} = 0.79$
A_s/A_a	= 0.729		$K_{s_2} = \frac{0.665}{1.445 \div A_s^2 = 0.001068}$
			0.002562

$h_o = 0.002986\ \ V^2\ (.002562) = 0.476$ " H_2O

$h_2 = 0.59$ $\qquad F = V/A_r\sqrt{\rho v} = \frac{3945}{315} - 0.00502 = 0.886$

$h_{ow} = 0.25$ $\qquad \phi = 1.411$

$\Delta/2 = 0.12$ $\qquad \phi s_t = 1.06$"

$s_t = 0.96 \times \frac{48.6}{62.4} = 0.748$ " H_2O

Total Tray Pressure Drop = $h_t = h_o + \phi_{s_t} = 0.595 + 1.06$

= 1.60" H_2O

About the Author

Welch

Harry T. Welch is a purchasing agent for Union Carbide Corp. in New York. His position at the company includes the purchasing of chemical raw materials. Welch was with The Texas Co. from 1949 to 1956 as a process design engineer, and he joined Union Carbide in September, 1956. He received a Bachelor of Chemical Engineering degree from Rensselaer Polytechnic Institute in 1949, and a Master of Chemical Engineering degree from the Polytechnic Institute of Brooklyn in 1956. The work on which Welch based his paper, "Pressure Drop Through Bubble Caps," was performed as part of the requirements for his MChE degree at Brooklyn Polytechnic under the direction of Dr. Ju Chin Chu.

6 steps to better DRAFTING PRACTICES

*A PETROLEUM REFINER Special Report prepared by Frank Evans, Maintenance and Design Editor

STEPPING UP DESIGN

TODAY'S DESIGN techniques will not be good enough for tomorrow's competition. Why? Because many of the present design drawing principles came from the past when emphasis was on the beauty of drawings as well as their practical value.

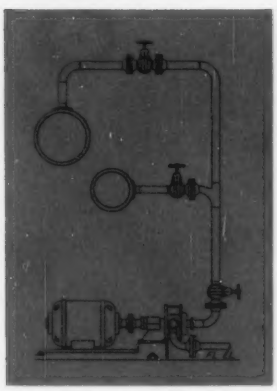
The first engineering drawings were made by artists such as Leonardo da Vinci. Most of the early engineers and draftsmen, while substituting the straight edge for lack of artistic skill, prided themselves in the artistic preparation of engineering drawings. It wasn't too many years ago that elaborate penmanship was the mark of distinction for an educated man.

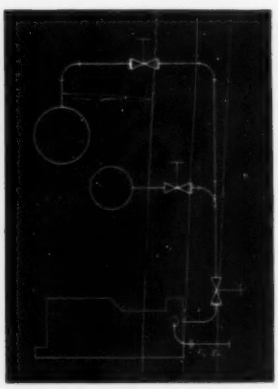
Artistic Drawings. How often have you seen the artistic type of piping drawing of a pump, motor and double line piping? Undoubtedly, it's a thing of beauty, but consider the drafting time involved. What does such a drawing propose to show? It probably doesn't indicate the exact pump, motor or frame dimensions. These are covered in the specifications and certified prints of the manufacturer. Thus, at most, the drawing shows the valve, flanges and piping connections between the pump and the header. Look at the simplified piping drawing. All of the pertinent information is contained on this single line outline drawing, and it can be accomplished in a fraction of the time required for the artistic presentation.

Excess Data. Lettering not only consumes too much of the designers time but also clutters up the drawing with information that could more easily be included in the specifications. The excess agitator data shown in the figure, aside from the time consuming aspects, adds nothing to the value of the proposed wash tank.

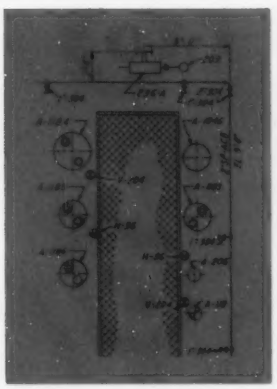
Excess Line Work. In the left hand "Line Work" drawing, the designer learned that he should use numbers

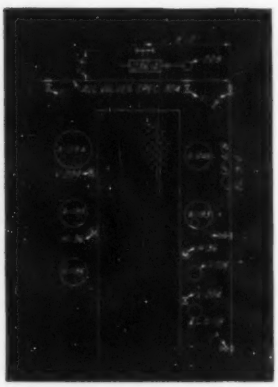
Traditional drafting practices too costly for today's competition



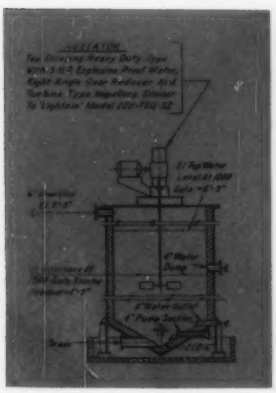


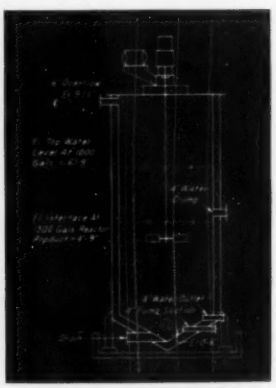
ART There's no information on the arty type of drawing (left) that's not described on the outline type drawing (right).



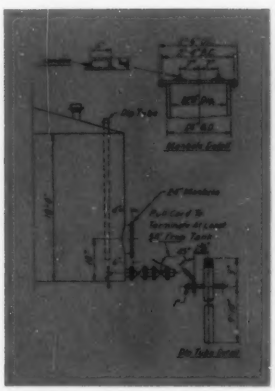


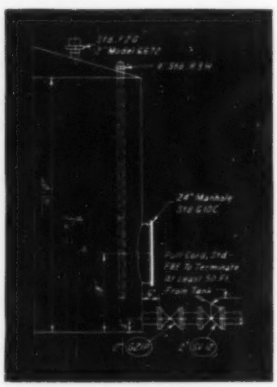
LINEWORK Cross hatching and arrows (left) not only clutter up a drawing but necessitate extra drafting time.





DATA The excess agitator data shown on the left adds nothing that cannot be covered better in the specifications.





DETAILS Standard details (left) made during times of slow work loads for fast construction drawings (right).

DRAFTING EFFICIENCY

to identify the equipment, but he couldn't resist using the long arrows pointing to the equipment. The effect, of course, not only increases line work time on the drawing but adds to the general confused appearance caused by the arrows running through the piping.

Details. When working on a construction drawing, it's difficult to resist the temptation to draw a detail, especially if the particular item is not clearly shown on the construction drawing. Why not refer to a standard detail which, if not complete, can be made during slack office periods.

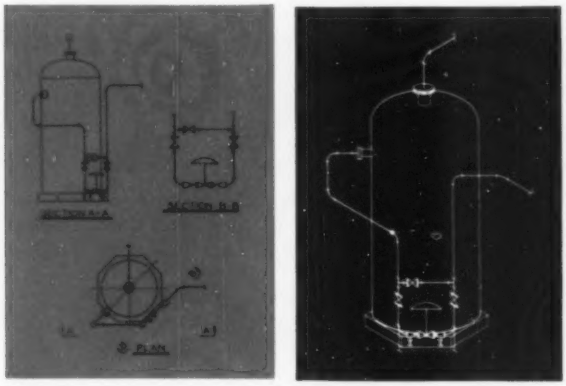
Extra Views. Isometrics are coming into their own, especially for piping drawings. Look how simple and easy it is to read the isometric piping drawing as compared with conventional methods. Another time feature is the lack of duplication, when using isometrics.

Time-consuming Lettering. Lettering looks good in magazines but they have machines to do the work. You can simulate a machine, in your drafting practice, by using a title box and tables for design data, on equipment that is used frequently, such as pressure vessels.

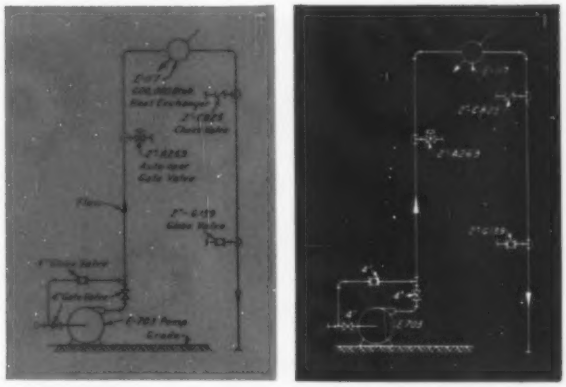
Spelling. Why spell-out the name of equipment items when you have a perfectly good symbol for it? Use either your own standard symbols or one of the standards societies' symbols —but use it and reduce lettering time. And, use the specification number. It's a more accurate item description.

Freehand. Oftentimes, there is a need for a small sketch such as the relocated piping drawing shown in the figure. Try making freehand sketches for these drawings. They may not look quite as pretty, but they will get the job done in a fraction of the time required for a line drawing.

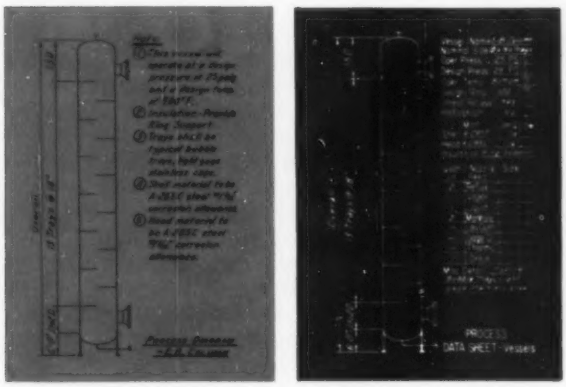
The keyword is "simplify." Follow these steps and cut your costs



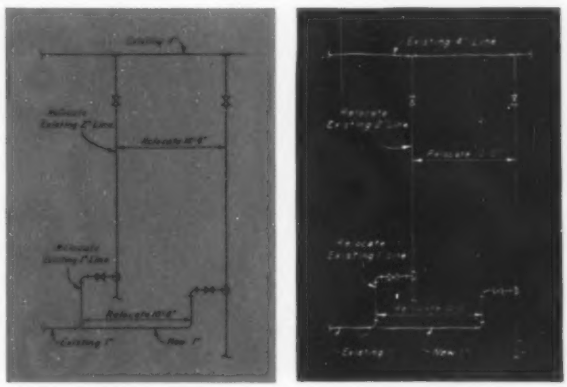
VIEWS Unnecessary views and duplicate information (left) are eliminated on isometric piping drawing (right).



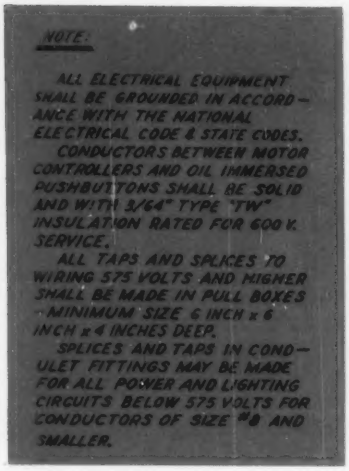
SPELLING Item names (left) provide no more field information than symbols and a specification number.



LETTERING Many items, such as vessels, are used often enough to warrant using preprinted forms for tabular data.



FREEHAND Sketch (right) is faster to make and may serve the same purpose as a line drawing.

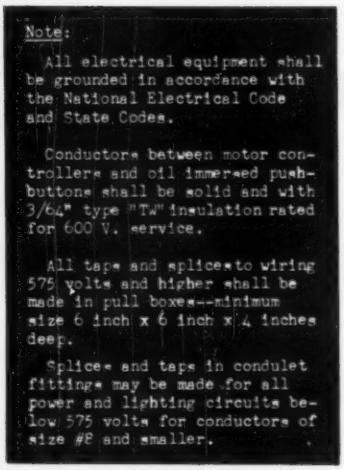

NOTE:

ALL ELECTRICAL EQUIPMENT SHALL BE GROUNDED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE & STATE CODES.

CONDUCTORS BETWEEN MOTOR CONTROLLERS AND OIL IMMERSED PUSHBUTTONS SHALL BE SOLID AND WITH 3/64" TYPE "TW" INSULATION RATED FOR 600 V. SERVICE.

ALL TAPS AND SPLICES TO WIRING 575 VOLTS AND HIGHER SHALL BE MADE IN PULL BOXES - MINIMUM SIZE 6 INCH x 6 INCH x 4 INCHES DEEP.

SPLICES AND TAPS IN CONDULET FITTINGS MAY BE MADE FOR ALL POWER AND LIGHTING CIRCUITS BELOW 575 VOLTS FOR CONDUCTORS OF SIZE #8 AND SMALLER.


Note:

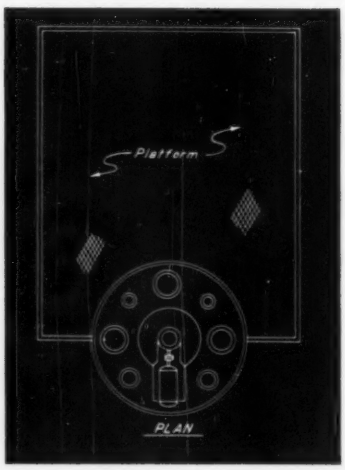
All electrical equipment shall be grounded in accordance with the National Electrical Code and State Codes.

Conductors between motor controllers and oil immersed pushbuttons shall be solid and with 3/64" type "TW" insulation rated for 600 V. service.

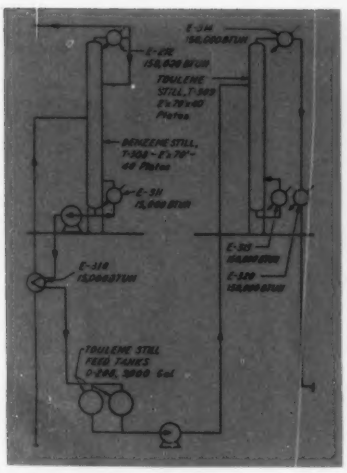
All taps and splices to wiring 575 volts and higher shall be made in pull boxes--minimum size 6 inch x 6 inch x 4 inches deep.

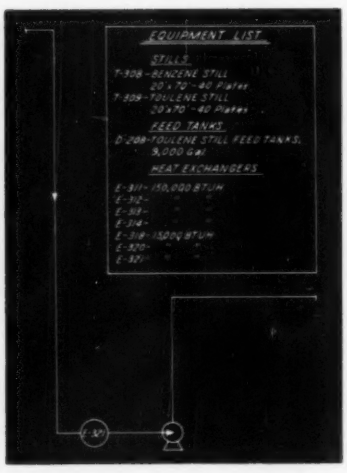
Splices and taps in condulet fittings may be made for all power and lighting circuits below 575 volts for conductors of size #8 and smaller.

GENERAL NOTES **Hand lettering voluminous general notes is time consuming and more difficult to read than typewritten notes.**



CROSS HATCHING **An expanded metal platform can be shown symbolically (right) saving 30 minutes time over a cross hatching job.**





SCATTERED NOTES **Equipment names and notes produce a drawing that is hard to read. Use box and collect data in one place.**

General Notes. There has been a reluctance on the part of some designers to confine their notes to the general and special conditions of the specifications. Too often they are tempted to include voluminous notes directly on the working drawings.

Some design sheets are of such a convenient size that they can be inserted in the typewriter. Backing sheets are available that impress a dye on the reverse side of the tracing to insure a good copy from the duplicating machine.

Cross Hatching. The main purpose of these recommended practices for your drafting room is the establishment of minimum requirements for a drawing without reducing the efficiency of construction and shop workers. One requirement that has probably been abused more than any other is the custom of cross hatching. It does "dress up" the drawing in many instances and sometimes cross hatching is necessary to clarify the various parts shown on the drawing. But, many times its practical value is negligible and could lead to confusion during construction. For example, the figure shows a platform elaborately cross hatched. The field worker could reasonably conclude that the cross hatching indicates that the platform is to be constructed with expanded metal when, in fact, the specifications may call for steel plate.

The general rule is to keep cross hatching to a minimum even when it is necessary for clarity or used as a symbol.

Scattered Notes. While working on a drawing showing equipment symbolically, the designer will often want to add an equipment description to the symbol. He may be following a flow diagram, as used in the example. When the flow lines enter a vessel, such as a benzene still, the designer's natural tendency is to letter-in a description of the vessel near its symbol on the drawing. He then follows the flow to the next piece of equipment and labels it.

Several difficulties arise out of such a procedure. The drawing is cluttered with notes describing each equipment item. Excess drafting time is required to locate each of these notes beside the equipment. And, another step in listing the equipment is required for the engineer reviewing the process.

A practical solution to this problem is to collect all of the scattered

notes and include them in a box which is generally located in the upper right hand corner of the drawing.

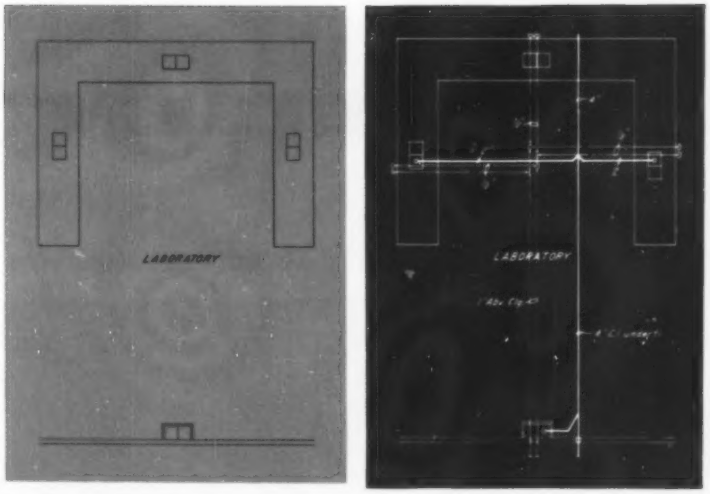
Reproductions. Background information is often essential to the engineering drawing. For example, the layout of laboratory equipment is a necessary part of the plumbing drawing for that equipment. The plumbing designer can save considerable drafting time by having a transparent print made of the architectural drawing before dimensions are added. With the background drawing on the print, the designer's time can be profitably spent in plumbing layout instead of time consuming background work.

Another variation of this method is to make both a transparent print and a "white" print of the background drawing. The designer can then sketch-in freehand, or with rough guide lines, the design details on the white print and let a draftsman trace the design drawing directly on the transparancy.

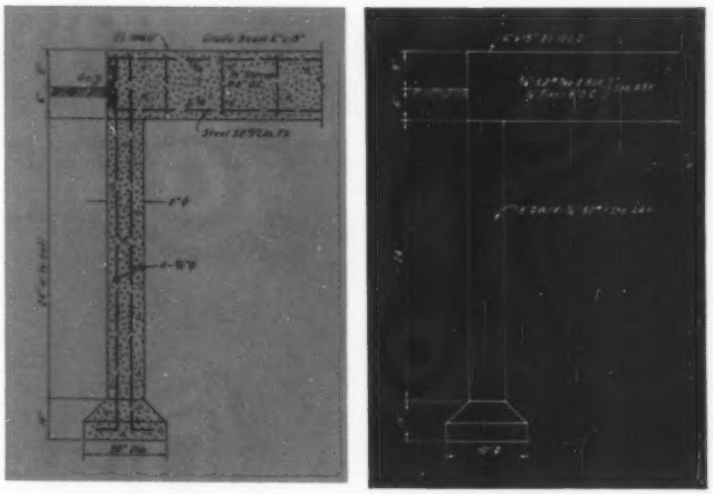
Specifying. Last year, Du Pont reported a $2.5 million saving in design and drafting time by the use of engineering standards. They are referred to on drawings by code number and cover all of the details and specifications which would ordinarily be included on a design drawing.

Take a look at the simplified method of showing the steel required in a foundation using the simplified standard reference method and the conventional symbolic method showing reinforcing rods, top and bottom, with stirrups and ties. Some dimensions will probably always be necessary to meet the conditions of the particular design. But, design details are often similar, or the same, and are probably shown better on a standard detail. The code numbers can be used to refer not only to standard details but also to give data on dimensions and materials.

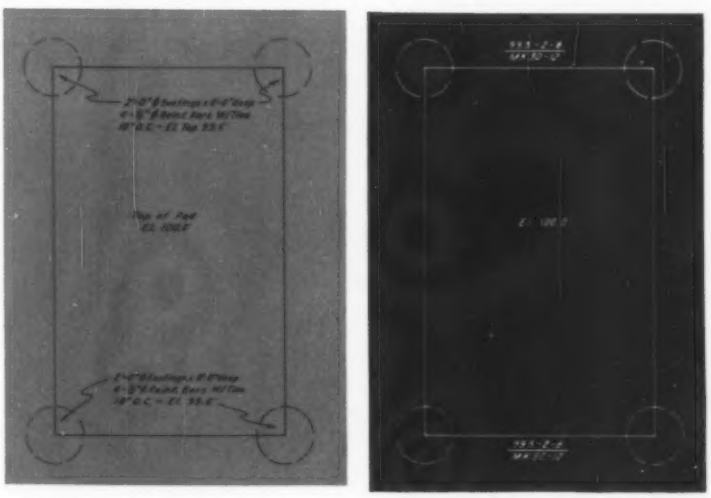
Coding. Fractional coding can be used to show all of the data concerning a particular detail. In the case of concrete footings, it is desirable to indicate the top elevation, the diameter and the depth together with a code reference to the reinforcing standard that applies. This may be accomplished simply by using the top line of the fraction to show the footing elevation, its diameter and depth. The lower line of the fraction contains a code reference to the appropriate reinforcing standard.



REPRODUCTIONS Save background drawing time. Plumbing drawing (right) was made on a print of the architectural drawing (left).



SPECIFYING Instead of showing all of the steel and concrete in a foundation, use the simplified method of standard reference for specifying.



CODING Fractional coding identifies a concrete footing by specifying its elevation, diameter and depth together with a reinforcing standard.

BOOST DESIGN OUTPUT BY

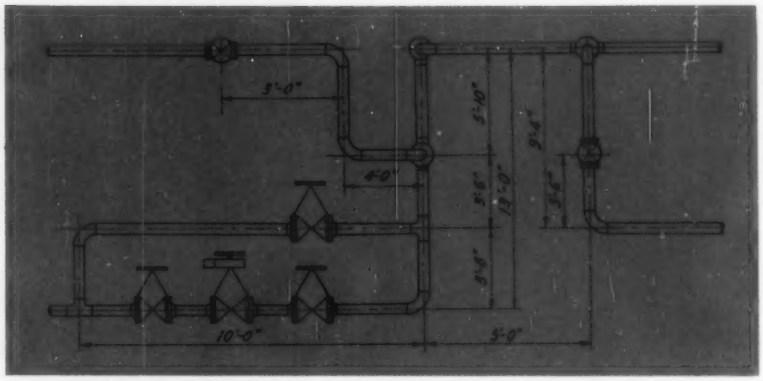
Three drawings? No—only one drawn three ways

ONE PHASE of design that always pleases management is to see the plant onstream ahead of schedule. Improved drawing techniques probably will contribute more to speedier plant construction than any other one single factor.

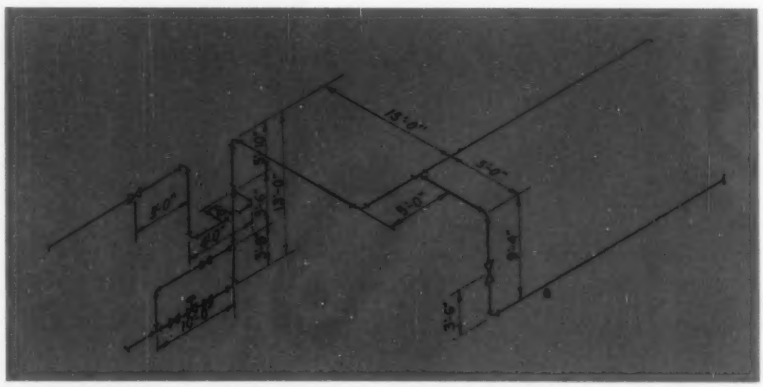
Take a look at the time required to make three identical piping drawings. All contain the same information. All were made by the same man on the same drawing board and under the same conditions. Suppose, however, that the only drawing available was the two line piping detail that took 85 minutes. Can the pipe be fabricated from this one? No, because three major dimensions are not shown. Therefore, the pipe shop would require another drawing possibly requiring an additional 85 minutes drafting time to give the information needed to makeup the pipe.

A 40 percent reduction in drafting time is possible when pipe is detailed using single line isometrics instead of the conventional two-line piping system. In addition to the saving in drawing time, the fabricator has all of the dimensions required and the drawing is easily understood.

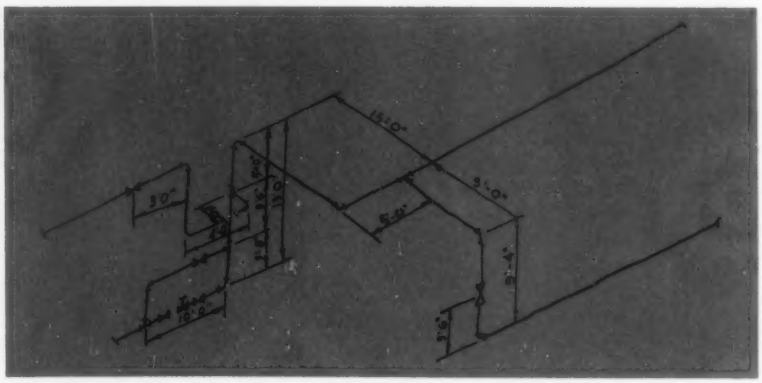
The freehand drawing duplicates the single line pipe detail. Although it is faster, it requires a pretty fair hand to make reasonably accurate and readable freehand sketches. However, many drawings do not require the precision ordinarily used on line drawings; thus, freehand sketches would be ideal in these cases. Sometimes, a length of piping is to be relocated in one of the process areas. The job is simple but a word description does not easily explain the present location of the line and its relocated position. The obvious solution is a small drawing which enables the field mechanic to visualize the existing line and its relocated position. Why not use a freehand sketch for these cases? He could complete the job while a line drawing is being made. So, give the mechanic something fast; something accurate and something to get



85 MINUTES These three drawings were made by the same man on the same drawing board, under the same conditions. It's hard to visualize this one.



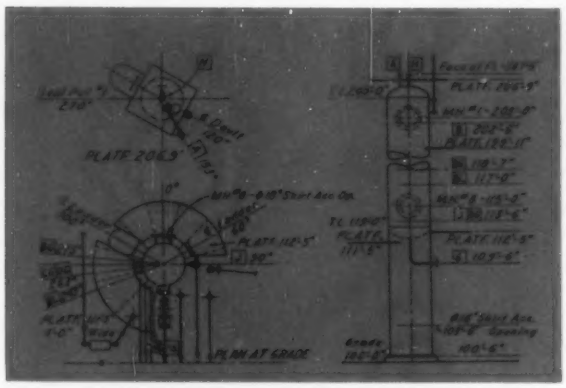
51 MINUTES This isometric view of the same piping system as above is easy to visualize and requires only 60 percent as long to make the drawing.

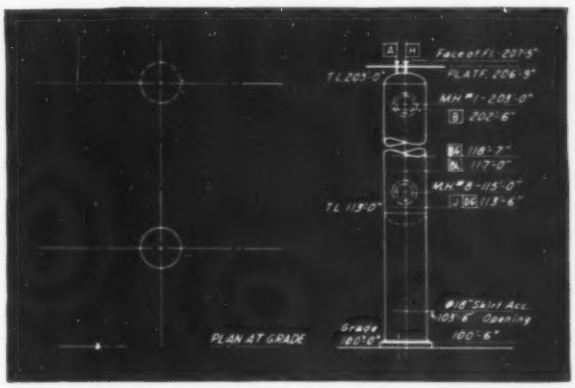


22 MINUTES For a big saving in time try a freehand sketch. It is much faster but requires a steady hand and is sometimes lacking in accuracy.

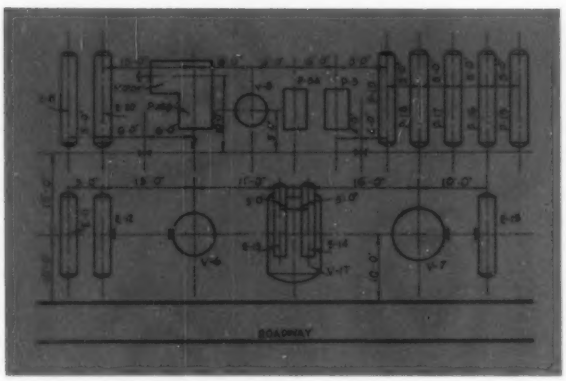
USING MODERN IDEAS

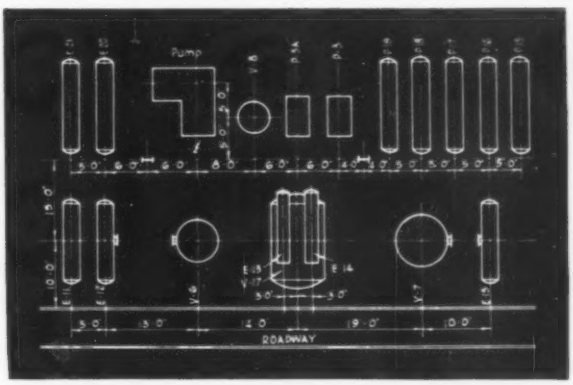
Preliminary drawings and plot plans can be simplified three ways



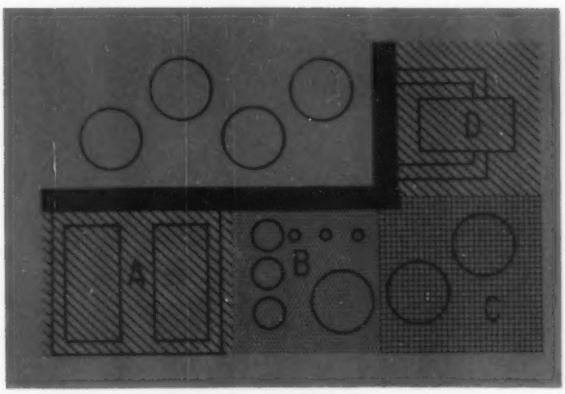


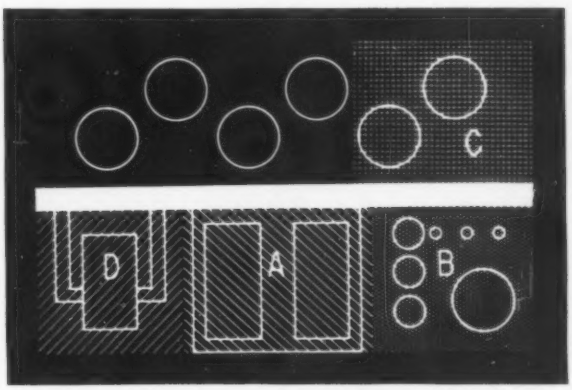
PRELIMINARY DRAWINGS Design studies do not require the detail of a fabrication drawing. The experienced designer can visualize the details. In fact, too many details may add to preliminary design study, confusion.



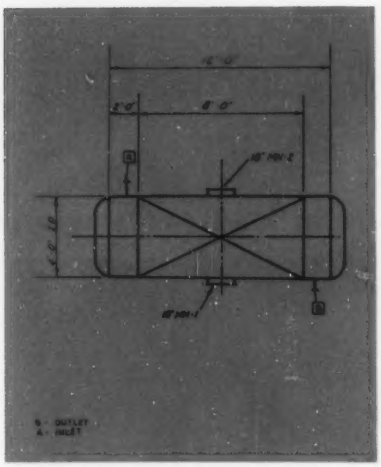


PLOT PLAN DIMENSIONS It's hard to pick out the dimensions when they run through the equipment, as shown on the left above. Run dimensions on the plan so they do not cover equipment and are easy to find.

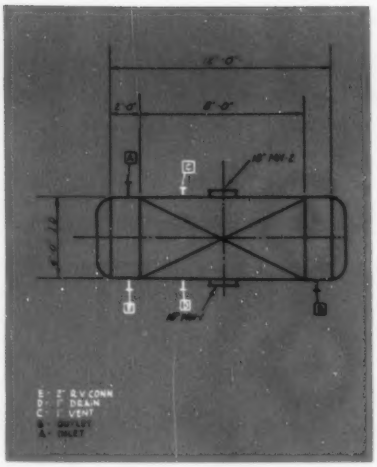




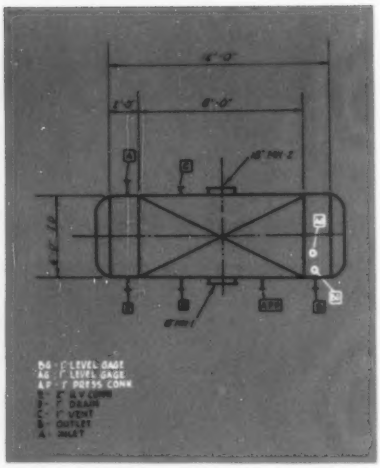
PLOT PLAN REARRANGEMENT When making a preliminary study, it is often desirable to shift areas around. An easy way to do this is to make tracing cutouts and attach the parts with a cellophane tape.



STEP 1 Show process needs: vessel position, its size, major connections manhole data and outline vessel internals.



STEP 2 Check piping requirements: all utility connections (drains, vents, etc.), nozzle sizes and nozzle rating.



STEP 3 Add instrument connections: obtain data from control diagrams and instrument data sheets.

the job done with the least cost—a freehand sketch will do all of these.

Preliminary Drawings. When a design group is studying a layout, detailed information may be a handicap instead of an asset. For instance, it is not necessary for the experienced designer to have nozzle details, platforms and other final design information before him in order to visualize the arrangement during a design study. Structural details should also be omitted at this early study stage.

All details and written information are necessary parts of the drawing when the tower is being fabricated in the shop; but, too much detail is often distracting and confusing during a preliminary study.

Plot Plan Dimensions. There is nothing more confusing than a plot plan with a string of dimensions running through the process area. Keeping dimensions away from equipment will make your plot plan easy to read. Plot plan information is generally of interest to more than one design group. Therefore, it is good practice to separate the dimensions for the interest of the various groups. For example, the structural dimensions should not be included with the piping dimensions. Piping dimensions may be classified as those which locate the reference lines from the plant limits, those locating the process equipment from the reference lines and those dimensions which locate the piping from equipment center lines.

Another common abuse of plot plan information is to locate equipment dimensionally in such a manner that the user is required to go through a long string of dimensions using time-wasting arithmetic before an essential measurement can be read from a drawing. The best step toward solving this problem is to plan your dimensioning with the user in mind.

Plot Plan Rearrangement. In the preliminary plant planning stage, it is often desirable to shift areas around on the plot plan for study purposes. This, of course, can be accomplished by redrawing the plan, but again this procedure wastes drafting time and is expensive. A simple study method can be used requiring only a reproducible print made from the original plot plan. Cutouts from this print are stuck together with cellophane tape to form the new arrangement. These cutout areas can be shifted around to form different plot plan combinations.

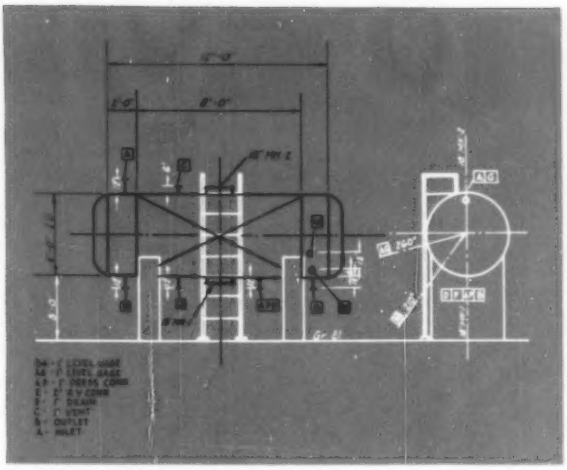
It's difficult to visualize equipment arrangements without some sort of reference drawing. Therefore, a cut-out method which allows you to study the maximum number of combinations with a minimum amount of drafting time is an extremely desirable procedure. This will undoubtably produce the best arrangement because of the many possibilities which are studied.

Vessel Design Steps. Assembly line methods can be adopted in the drafting room. Finished drawings, being the product, start as a sheet of white tracing paper. Between the white paper and the finished drawing stages, the choice is up to you whether a drawing should be considered a manufactured item or a specialized product requiring custom retooling for each new product.

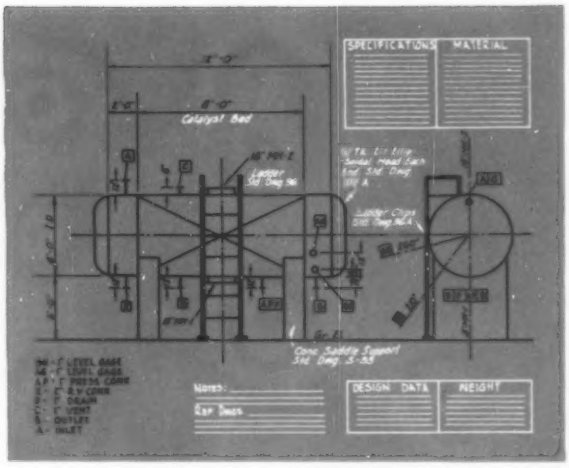
Custom made items are always more expensive because of the planning required for each step. Why not remove some of those planning steps? Even though each drawing is tailored for its particular function, logical steps can be taken which will put it on an assembly line basis. This will not only reduce the drafting time, but will also assure the designer that all of his required data are included.

For example, look at an assembly line method of designing a process vessel. The first step is dictated by the process requirements. The vessel size, position and internals, together with manholes and process connections are included. Location of the vessel on the tracing has been established before the design begins, so valuable time is not lost in planning the drawing.

The second step is the making of a piping analysis. The designer considers the utility connections required on the vessel and includes their size and ratings on the drawing. Dimensional accuracy is not required at this stage. This illustrates another



STEP 4 Items in previous steps are physically located: vessel elevation, nozzle connections, platforms and ladders, vessel supports and the equipment is oriented.



STEP 5 Final design information is added: specifications, materials of construction, code requirements, and any final notes that will assist in the vessel fabrication.

advantage of the step-by-step system. The designer considers only the step he is working on. It's the same as an automobile assembly line. Using custom built methods, the designer worries whether or not the engine will fit the frame when the two come together. With the assembly line, the designer considers only the problem before him and doesn't worry about problems down-the-line.

Instrument connections are made in Step 3. This information is obtained from process control diagrams and instrument data sketches. Level gage locations and pressure measuring points are located in this step with their sizes being added to the list of vessel connections.

The actual location of all connections is completed in Step 4. Elevations, platforms, ladders, supports and orientation are all performed in this step. A plan or end view is drawn which provides a means of orienting the nozzle connections.

The final step in vessel design is to add the specification and design notes to the drawing. At this point, you should consider any code requirements along with stress calculations. Any notes that will assist in the fabrication are added.

Thus, in five steps, a blank sheet of tracing paper has gone through the drafting assembly line in an organized, methodical manner. Everything about the vessel has been considered and vessel design time has been materially reduced.

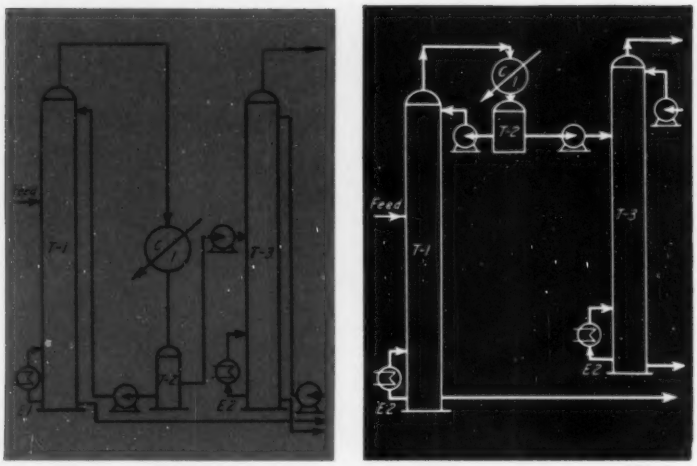
Summary of ways to cut your design and drafting costs with time savers

Try these recommended drafting cost savers: make drawings functional by reducing the art, omit the excess data, reduce linework, use standard details, eliminate extra views, try printed forms to cut hand lettering, refer to items by symbol and specification number instead of spelling out the name, consider freehand sketches for small jobs, do not hand letter general notes, use cross hatching sparingly, collect scattered notes in a box, try reproducible prints for background information, instead of showing construction details, such as steel, refer to a standard, and use fractional coding to specify footings.

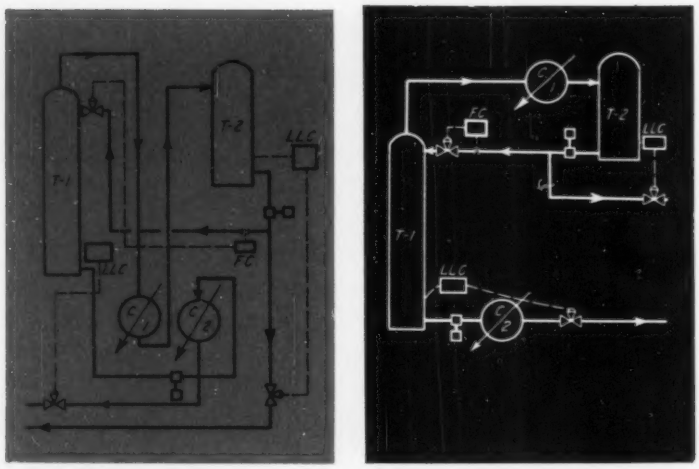
Try these labor savers: Slash piping drawing time 40 percent by using single line isometrics where possible instead of two line drawings. Freehand piping sketches can further cut this time in half. Use very little detail on preliminary study drawings. Keep plot plan dimensions away from the equipment. Try cutouts from reproducible tracings for plot plan rearrangements.

Use five steps in assembly line vessel design:

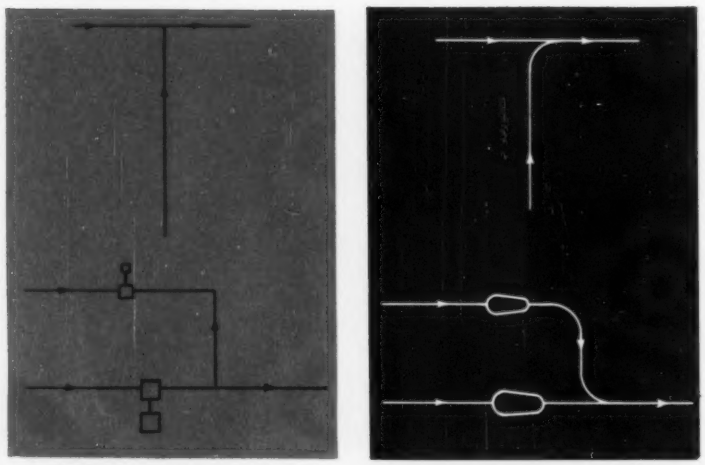
1. **Process needs**
2. **Piping requirements**
3. **Instrument connections**
4. **Dimensioning**
5. **Specifications**



FLOW SHEET LAYOUT Process flow sheets are much easier to follow when the major equipment is not on the same base line.



INSTRUMENTATION The first step in simplifying control diagrams is to rearrange flow lines making them as short as possible.



BETTER SYMBOLS? New ideas on flow sheets includes the curving of an intersecting process flow line to show flow direction.

Process Flow Sheets

Nothing is more symbolic of process engineering than the flow sheet. It summarizes all of the design calculations and presents, in pictorial form, the thinking of the process engineer. It is, of course, only symbolic of the actual physical layout of the unit. Yet, many designers insist that all of the major equipment be located on the same base line. Take a look at the first figure in this section. By observing a base line rule, the designer was forced to lengthen all of the flow lines and include several extra flow ells that would not be required had he abandoned the base line rule. Just a glance will show you how much easier it is to follow the flow lines where the equipment is located on the flow sheet for simplicity in following the process.

Another step in improving the readability of flow sheets is to make the flow lines heavier than the equipment lines. The sequence of the process can be followed much easier and faster.

Instrumentation. In adding instrumentation to a conventional flow diagram, the result is an even more confusing jumble of lines. Instrument air lines run parallel to flow lines and often cross them. The first big step to take in improving the diagram is to rearrange the process equipment in order to have the shortest reasonable flow line pattern.

One interesting idea developed for instrument air-line drawings is to show the air-line dotted from the pressure or temperature points *always* sloping in a downward direction to the control valve or meter.

New Short Cut Ideas. One shortcoming of flow diagrams is the inability to see immediately the direction of flow when two lines connect. For example, if one flow line ties into another with a tee connection, it requires more than a glance to tell if the flow is to the left or right in the connecting line. A solution to this problem is to make the connection with a curve such as might be seen when two 90 degree trolley tracks connect with each other.

Another complaint has been the extra drawing required to make a pump symbol. A solution has been offered that makes the pump look pear shaped. It requires less drafting time and the inlet is always on the large end of the symbol while the discharge is on the small end.

PHOTOS ARE SUPERFAST

Probably the fastest method for giving field instructions is by using photography. When alterations or additions are necessary for a plant, the designer can instruct the plant photographer on the precise angle required in the photo to show the existing facilities.

Two methods can be used by the designer to show the changes. In the first, the photograph is converted into a photo-tracing and the designer uses pencil or ink to add the necessary modifications. Omissions are either eradicated with a special fluid or marked out with a zigzag line if it is necessary to show piping and/or equipment that is to be removed. New lines are drawn on the photo-tracing just like any other tracing (only a little heavier), and prints are made by conventional tracing reproduction processes.

The second method is to make a regular, glossy print of the photograph. Alterations are made directly on the face of the print with a grease pencil, and any mistakes are corrected quickly with an ordinary rubber eraser.

Because of the heavy lines made by a grease pencil, detail is difficult to obtain and notes are unusually large. But, this method is fast and prints are easily made on a conventional photostat machine.

DRAWINGS FROM PHOTOS A glossy print marked with a grease pencil and photostated makes a fast field alteration drawing.

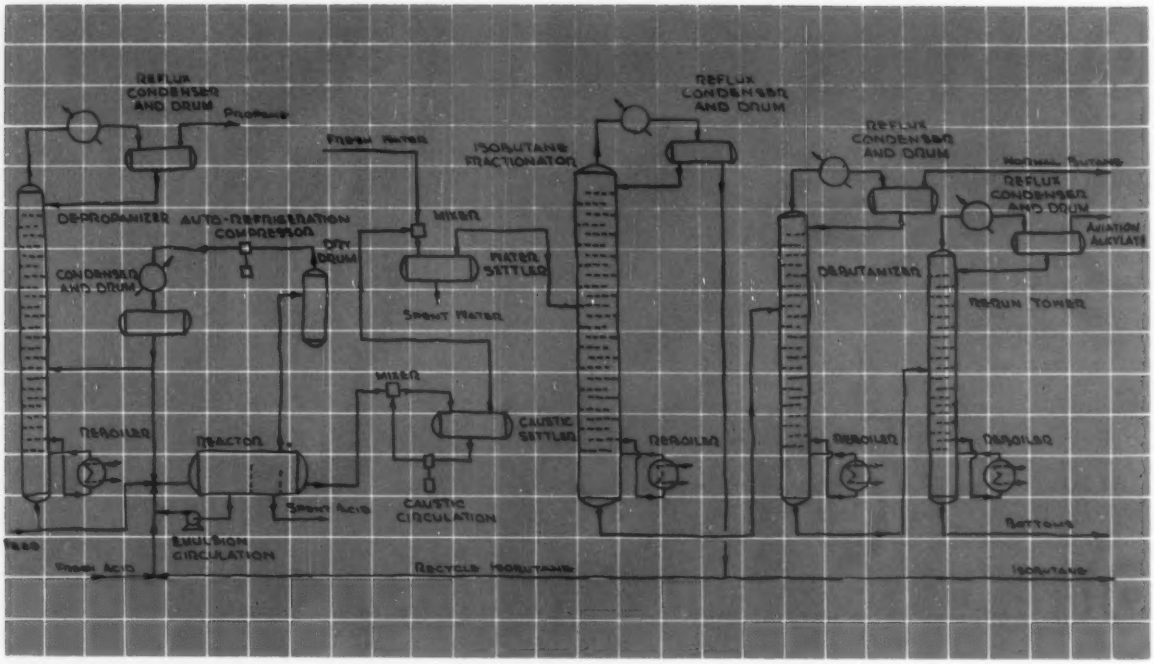
FREEHAND TECHNIQUES

Whenever the subject of drafting techniques is discussed among two or more engineers, someone will usually mention engineering freehand drawings. While there will never be a big rush to use this method, here are some pointers and a few trial sketches of freehand drawings which may convince you of its advantages.

The most difficult part to perform in freehand work is the drawing of a straight line, to scale. This problem can be completely solved by using graph paper with lines that do not print on reproduction. It takes very little artistic or drafting skill to follow a line on the graph paper. Even though your line may be a bit wiggley, it will show your ideas quickly, graphically and to scale. Another big advantage of the technique, especially for process flow diagrams, is that it can be used at a comfortable desk without resorting to the altitudes of a drawing board.

During the process of preparing a single line drawing, the draftsman ordinarily picks up and puts down his scale rule many times. The use of preprinted grid lines practically eliminates the continual scaling required on conventional tracing paper. Proportions are easier to visualize and dimensions, equipment spacing and piping are easier to set through the use of grid lines. These lines are extremely light and do not appear on the print, so they are really a drafting aid.

Another must for the designer drafsman who is looking for cost cutting techniques is the automatic pencil. When using fast drafting methods like freehand drawing, a dull pencil point becomes even more noticeable.



GRID SPEEDS FREEHAND SKETCH

Solve the problem of drawing straight lines freehand by using graph paper. A big advantage of freehand drawings is the ability of making them comfortably at your desk.

Summary of Rules for Freehand Drawing

Use paper with preprinted grid lines that will not reproduce for your freehand sketching. Pick out drawings that are not too complicated and make them comfortably at your desk. Use the grid lines as a scale instead of the conventional rule. Try automatic pencils using soft lead in one and hard in another. Use a small, portable drafting board. Draw lines continuously with little movement of the hand —never redraw the line when making freehand sketches. Do not rush the sketch. It is an engineering drawing and requires patience and thought. Most of all, get yourseif into the frame of mind that you will try freehand drawing. This technique works especially fast on alternate designs.

It's not that the technique requires more graphite on the tracing, the dull feeling occurs simply because more lines are being drawn in a shorter time. The push button, automatic pencil can be sharpened on a sanding block right at your desk. Drawing lines will be more consistant in weight and by alternating between hard and soft leads, it's easier to draw thin lines, such as center lines, contrasted with heavy piping lines.

Attaching the drawing to the board or desk seems like a small item but in reality it is time consuming. A customary procedure is to align the tracing paper with a straight edge and then attach the paper to the board with drafting tape. One short cut method, when using preprinted sheets, is to cut slits in the tape where you can insert the corners of the sheet. Then drawing a standard, parallel line on the board, the tracing paper can quickly be aligned without using a parallel rule. Freehand sketches can be made even faster. Since they are usually not large drawings, they may be attached with drafting tape to a one inch thick, portable drafting board, without the inconvenience of lining them up with a straight edge.

The actual method of applying the pencil to a freehand sketch requires some explanation. Lines should be drawn continuously with as little movement of the hand as possible. A rule might be: never turn back once the line has been drawn.

One very careless habit many freehand sketchers have is that they try to rush the sketch, the result of which is a third grade attempt at the Mona Lisa. The freehand sketch is still a precision enginering drawing and requires the same patience and thought that is evidenced on a conventional line drawing.

The biggest obstacle to overcome is the conventional draftsman's reluctance to try freehand sketching. It requires an open mind and the will to try something new. The flexibility with freehand work in making alternate designs quickly may be the incentive key to a greater use of this method.

ISOMETRICS FOR PIPING

ISOMETRIC DRAWINGS are pictorial in nature and are ideally suited for piping drawings since they leave little to the imagination. However, because of their three dimensional qualities, some details tend to be obscured.

To be useful, a true isometric must be opened or stretched out of the exact true projection to show the hidden detail. The drawings are not made to scale and only the proportion needed to balance the views is maintained.

The first figure on this page illustrates the true isometric piping drawing. Details are almost impossible to visualize because, from the eye's line-of-sight, two vertical pipes appear to coincide. The first step in correcting the illusion that two pipes occupy the same position is to spread the conflicting vertical pipes apart. The second departure from the true isometric drawing is to show a break in a line if it crosses another line. In other words, there are no hidden lines because either the drawing is stretched slightly to prevent parallel lines from coinciding, or a break is used to show a line that would otherwise be hidden.

Dimensions are much more easily understood by separating the conflicting lines. In fact, the true isometric drawing has so many dimensions for the same line that it would be virtually impossible for the field crew to visualize and construct the piping from such a detail.

Piping details often contain 45-degree lines running in a horizontal or vertical plane. A 45-degree line projected in an isometric drawing becomes either a vertical or horizontal line. Without some additional information, the reader is at a loss as to whether the pipe is actually a vertical line or a 45-degree line. It is easily understood on the plan view, but when the same piping detail is drawn isometrically, it is difficult to visualize the line.

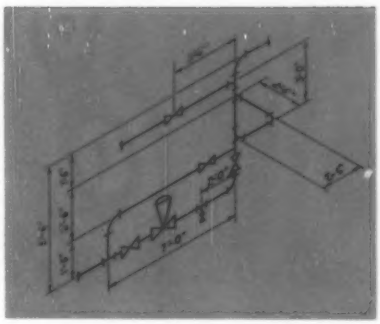
A method you can use to make your drawing more readable is to construct an isometric square in the same plane in which the pipe is running. The plane is easily understood to be horizontal, in this case, because no two sides are vertical. If the 45-degree line was in a vertical plane, the problem of visualizing the line would not exist since it would appear as a horizontal line on the drawing. There is no conflict because horizontal lines are drawn at 30 degrees to the bottom edge of the tracing.

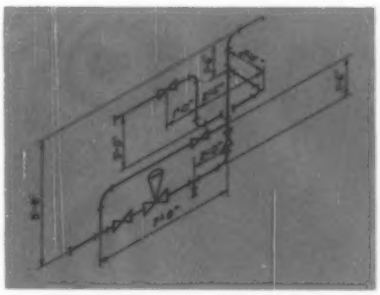
The 45-degree lines are nonisometric lines since they are neither horizontal or vertical. Because of this, the isometric square method was devised to help the reader visualize these lines in isometric drawings. Dimensioning of 45-degree lines is no problem when the isometric square system is used, since the dimensions of the square sides provide all of the information required for these lines.

For angles other than 45-degrees, an isometric rectangle is drawn enclosing the pipe in the plane in which the pipe is run. Two sides of the rectangle are dimensioned, the same way 45-degree lines are handled.

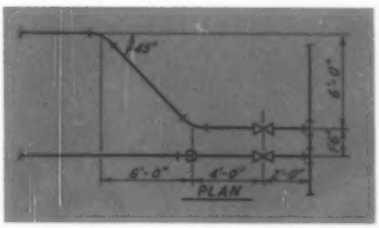
A somewhat more complicated situation arises when the pipe is run in a plane other than the horizontal or vertical. It's difficult for the reader to visualize this third dimensional shift in direction without an assist from some familiar reference. So, use the cube to help your reader make the transition from one horizontal or vertical plane to another. The cube simply frames the pipe as it enters one corner of the cube, travels through it and comes out the opposite corner. These piping lines further complicate isometric drawings because they are not only nonisometric lines but they also lie in a plane that is at some angle to a horizontal or vertical plane.

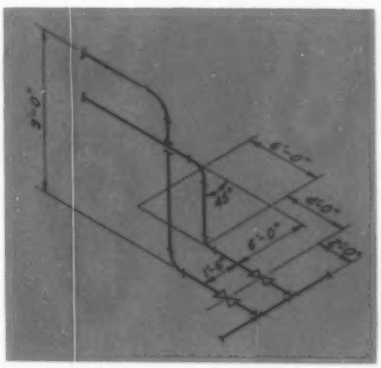
The first figure on Page 14 shows a side and end view of an orthographic piping detail. This same detail can be shown in only one view, isometrically (**B**), but the nonisometric line, lying in some plane at an angle Θ to a vertical plane, must be



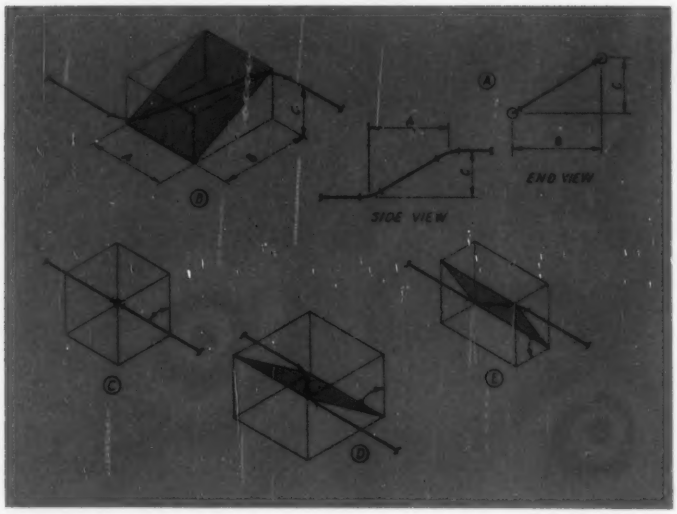


CONFLICT Lines fall on top of each other in true isometrics.

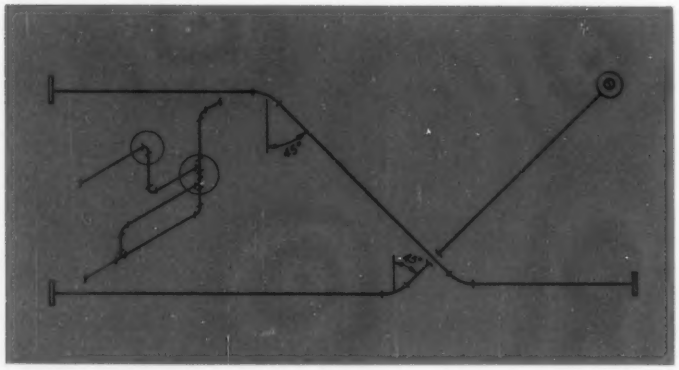




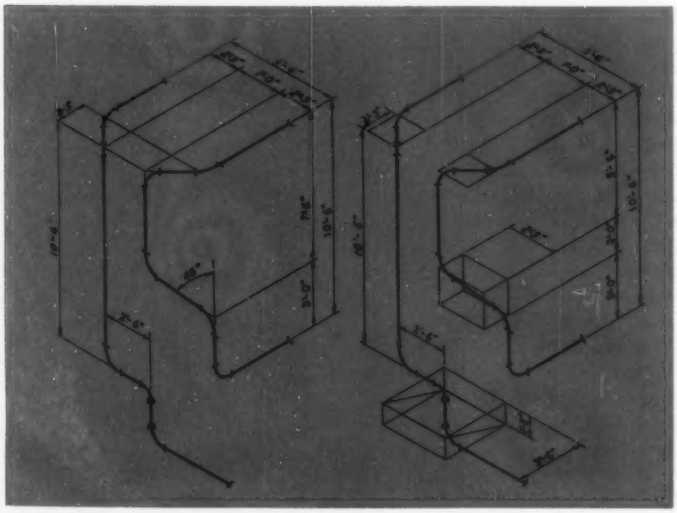
45° LINES appear vertical when using isometrics. Framing it in a square helps to visualize the drawing.



CUBES Non-isometric lines can fall in the cube's diagonal plane, C. By spreading apart the lines, the reader can see the drop, D.



PIPE DETAILS The straight offset (upper left to lower right) and the corner offset are most common non-isometric lines.



VISUALIZE By enclosing non-isometric lines in squares and cubes, the reader can visualize the drawing and dimensioning is a snap.

enclosed in a cube to visualize and properly dimension the line.

Sometimes a nonisometric line drops in exactly the same plane as the diagonals of the cube being used to clarify the position of the line (**C**). To make the cube method useful, the continuous lines must be opened or stretched apart slightly (**D** or **E**) to show that the line does travel through the cube by entering at one corner, and coming out at the opposite corner.

The most common nonisometric lines found on piping drawings are the two large diagonal lines shown orthographically in the second figure. These details are called the straight offset (upper left to lower right in the figure) and the corner offset. They may be found in isometric projections in either the vertical, horizontal or some nonisometric plane and should be enclosed with either an isometric square or cube.

The small detail in the second figure illustrates a valuable rule of thumb for isometric drawings. The circles enclose symbols used to indicate fittings. The rule for drawing these symbols is that they are always drawn parallel with the line they connect. Follow the rule and the direction of these symbols will always be correct.

The last drawing in this series on isometrics shows, on the left, how difficult it is to visualize nonisometric lines without the aid of squares and cubes. The symbols used to show fittings are not enough to dispel the illusion that two of the lines are running vertically and horizontally, respectively. The exact points from which dimensions are given is not clear. These problems are all solved in the drawing on the right. The piping is easy to visualize and dimensions are clear.

Isometric drawings have an important place in piping drawings but you should not attempt this technique for all detailing purposes. Complex and intricate pipe detailing jobs can be shown better by the conventional orthographic system. Many complex piping jobs may be handled with isometrics, providing of course, the draftsman has the necessary skill.

There is an increasing trend in the field of pipe detailing to use isometrics. The advantages of increased drafting speed and readibility have boosted this system's popularity in the last few years.

DRAFTING ROOM TIPS

DESIGNERS AND draftsmen are always on the lookout for drawing room tips that save time. Here are a few that will not only qualify as time-savers but are fun to work out. Try them and see!

Approximate Ellipse. Draw in the major and minor axes **AC** and **BD.** Construct a perpendicular to line **AD** which intersects a perpendicular to **BD** at point **E.** Draw the line locating x and y which become centers for the arcs shown. A french curve is needed to complete the ellipse because the arcs are only approximate and do not intersect.

Small Angles. Have you ever needed to draw a small angle, 10-degrees or less? A protractor is fairly good but not as accurate as this method. Draw a fixed length line, such as a three inch base line, and construct a perpendicular to it. The length of the perpendicular line is based on the following relationship: 3 x 0.01745 x the number of degrees being shown, (0.01745 radians = one degree).

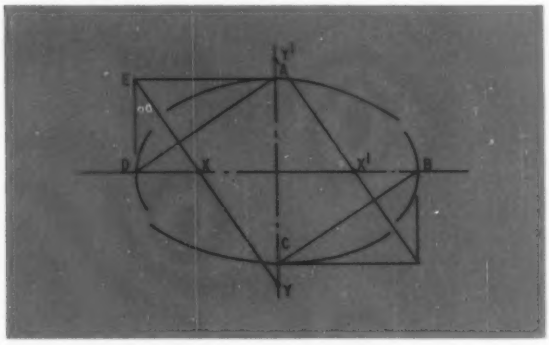
Perpendiculars. An easy way to draw a perpendicular to a base line that's not horizontal or vertical is to scribe one on your 45-degree triangle. Put the base of the triangle on the known line and a pencil point does the rest.

Cross Hatched Lines. A piece of masking tape placed on a triangle parallel to the edge makes a good reference for equal spacing of cross hatched lines.

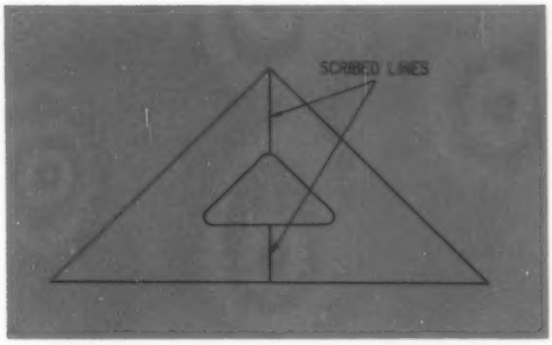
Radial Lines. A fast method to draw radial lines is to stick a straight pin into the drawing board at the center of the circle. By holding your triangle against the pin, you can draw any number of perfect radial lines.

Spaced Lines. Scribe lines on your

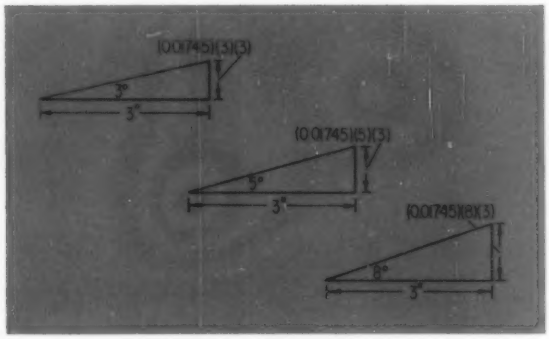
These tips will not only save time for you but are fun to work out



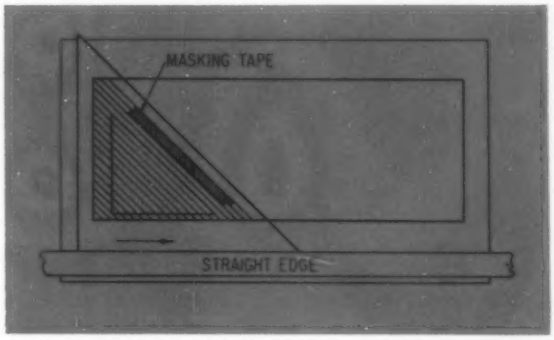
ELLIPSE It's easy to construct an ellipse by drawing a perpendicular to AD and locating points x and y which become arc centers. A french curve completes the job.



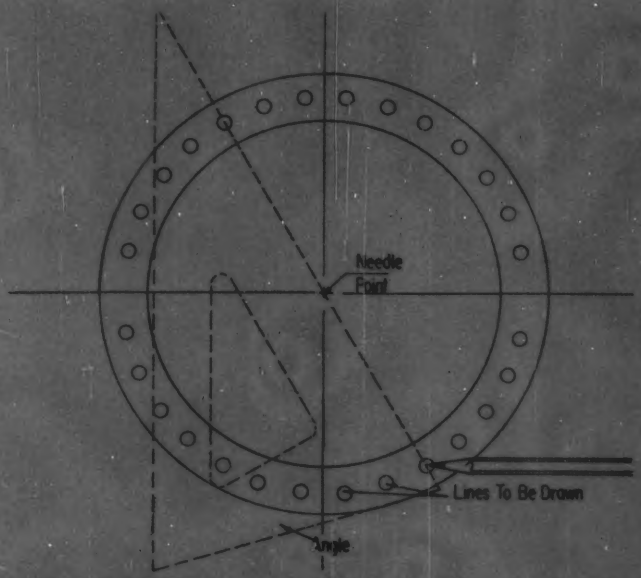
PERPENDICULARS Drawing perpendiculars to lines that are not horizontal or vertical can become tedious. A scribed line on an angle makes the job easy.



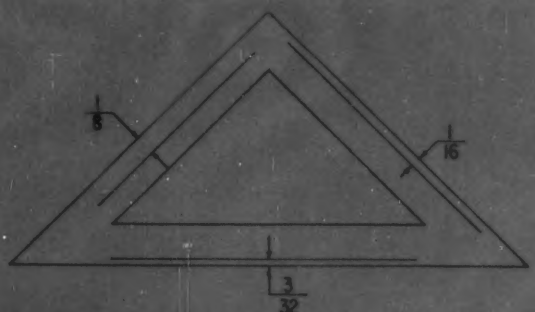
SMALL ANGLES Construct angles of less than 10 degrees quickly by drawing a base line and a perpendicular to it. The length of the perpendicular is equal to the product of the base, the number of degrees and 0.01745.



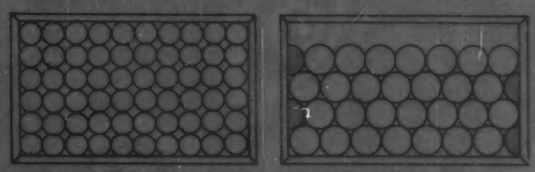
CROSS HATCHING is at the very best a time consuming job. But, it can be speeded by using masking tape on your triangle parallel to one edge. When cross hatching, line up the tape's edge with the previous line drawn.



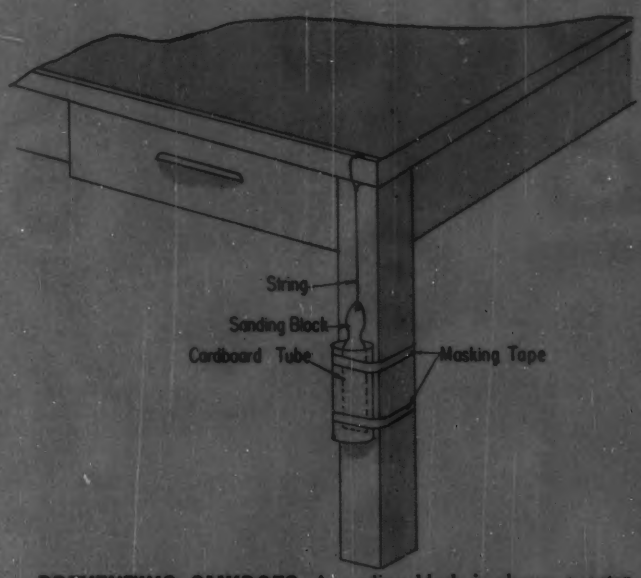
RADIAL LINES A common pin inserted at the center line of a circle makes the drawing of radial lines easy. Hold a triangle against the pin and draw the required lines.



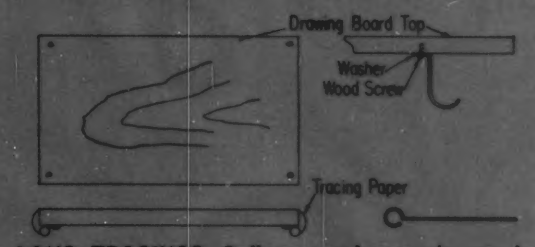
SPACED LINES By scribing three commonly used lines on a transparent triangle and placing over lines already drawn, parallels come out perfect.



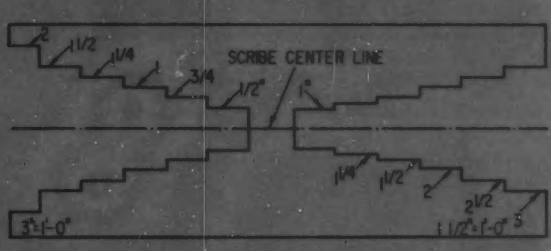
STORE TRACINGS in tube racks in which two tubes have been halved and glued to the sides. Withdrawing one tube will not disturb the rest.



PREVENTING SMUDGES A sanding block is always a potential source of trouble. Hang it by a string so it falls inside a section of cardboard mailing tube.



LONG TRACINGS Ordinary coat hanger wire may be attached to a drafting table to keep either or both ends of a long tracing from hanging down.



PIPE TEMPLATE The need to scale your piping drawings can be eliminated by cutting a plastic sheet to the most commonly used pipe sizes.

45-degree triangle at three common intervals, then place one of the scribed lines over the line already drawn. The result is two or more lines spaced quickly and accurately the desired distance.

Other tips shown, such as preventing smudges, storing tracings, holding long tracings and pipe templates, are but a few of the time saving devices and ideas available for the modern designer draftsman.

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Check Towers for Three-Way Stress

Here's a simplified method for calculating which triaxial stress governs in tower design.

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PRESSURE VESSELS, columns, slender towers, and stacks are frequently subjected to several simultaneous stresses, whose action is combined. Therefore it is necessary to establish the combined stress that determines the failure of the material used. For ductile materials, marked plastic deformation is generally considered as an indication that elastic failure has occurred.

The 1957 addenda to the 1956 edition of the Unfired Pressure Vessel Code considers the subject in Par. UA-274. This article is an amplification of the problem and its solution.

Three theories of failure are presently used. The "Maximum-Strain Theory," the "Constant Energy of Distortion Theory, and the "Maximum-Shear Theory." For ductile materials the Distortion-Energy Theory agrees best with experimental data. However, the Maximum-Shear Theory is very simple to apply and when compared with the Distortion-Energy Theory, the variation of the results are slight.

The Maximum-Shear Theory states that for a case of combined loading, elastic failure occurs when the maximum shear stress equals or exceeds the elastic limit in shear.

A cylindrical pressure vessel has a state of triaxial stress induced in the walls when the vessel is subjected to internal or external pressure and supplementary external loadings. Paragraph UG-22 of the Unfired Pressure Vessel Code defines the usual loadings to consider. For a state of triaxial stress, a maximum shear stress occurs on each plane. If each plane has simultaneously two stresses and whose line of action is at right angles to each other, then each plane may be analyzed as a case with biaxial loading. The maximum of each of the three possible commbinations must be equal to or less than the maximum allowable working stress for the material used.

Consider a unit element extracted from a body under biaxial stress, Figure 1. S_A and S_B are the principal stresses, the larger of the two is called the maximum, and the smaller is the minimum stress. The shear stress is equal to S_S

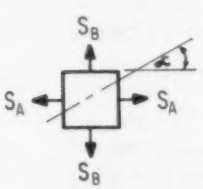


Figure 1

$$S_S = \tfrac{1}{2}\,(S_A - S_B)\,\sin 2\alpha$$

If S_A is assumed to be the maximum, the maximum shear stress is $S_{S_{MAX.}}$ $S_{S_{MAX.}} = \tfrac{1}{2}\,(S_{A_{MAX.}} - S_{B_{MIN.}})$ when $\alpha = 45°$ and 135°. Therefore, since the maximum shearing stress is equal to half the difference between the maximum and minimum principal stress, and applying the maximum shear theory as stated previously, the condition for yielding may be expressed as follows: $\tfrac{1}{2}\,(S_{MAX.} - S_{MIN.}) = \tfrac{1}{2} S_{Y.P.}$ Y.P. = Yield Point. Eliminating the factor $(\tfrac{1}{2})$ and expressing the relation in terms of allowable stress

$$S_{MAX} - S_{MIN} \leqq \text{Allowable Tensil Stress}$$

The state of triaxial stress in a vessel may be resolved into the following components, Figure 2.

1. S_C = circumferential or hoop stress
   due to: p = internal or external pressure
2. S_L = longitudinal stress
   due to: S_P = pressure on end closure
   S_W = weight of vessel and appurtenances
   S_E = overturning moment caused by wind, seismic forces, eccentric loading, pipe thrusts.
3. S_R = radial stress
   due to: p = internal and external pressure.

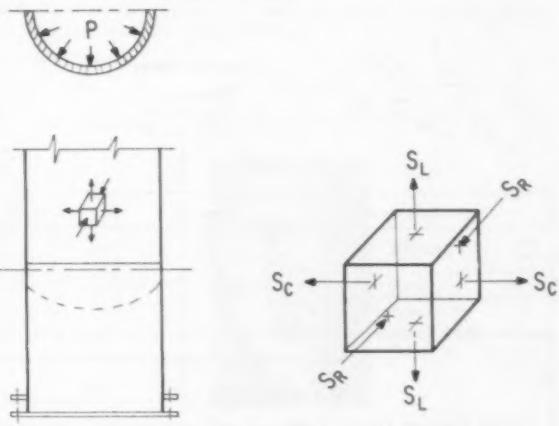


Figure 2

Thin wall vessels may be classified as such if the wall of the vessel is less than one-tenth (0.1) of the inside radius. In thin walls it may be assumed that the circumferential and longitudinal stresses are uniform throughout the shell thickness.

For a vessel with internal pressure, the maximum value of S_R is equal to the design pressure of the vessel and is a compressive stress. The minimum value of S_R is equal to the atmospheric pressure. Since for design purposes all pressures are denoted as gauge pressure

based on atmospheric pressure = 0, it may be assumed that the minimum value of $S_R = 0$. The maximum value of S_R (equal to the design pressure) is invariably less than the circumferential stress (S_C) or longitudinal stress (S_L). Therefore, the only value of S_R that requires consideration is its value of zero as a possible minimum principal stress.

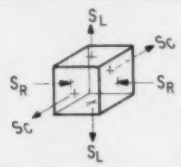
In combining stresses it must be remembered that the resultant of several stresses acting together on the same plane is the geometric sum of their individual actions. But stresses acting on different planes cannot be combined like forces. To simplify the combination of stress, the stress values may be tabulated in the following Tables 1 and 2.

For externally applied loads, the terms "Nearside" and "Farside" will be used to designate the point being considered, relative to the applied load. This will correspond to the windward side and leeward side for wind-loads. Convention of signs for stresses are taken with a (+) sign for tensile stresses, and compression stresses with a (—) sign.

TABLE 1—Principal Stresses (Max. and Min.)

	Circum. Pressure Stress S_C (+)	Radial Stress S_R (±)	Longitudinal Stress $S_L = \Sigma(S_P + S_W + S_E)$			
			Pressure S_P (+)	Weight S_W (—)	External Loads S_E (±)	S_L (±)
Nearside						
Farside						

TABLE 2—Maximum Shear Stress



Principal Plane	Principal Stress
Plane No. 1	S_L and S_R
Plane No. 2	S_C and S_R
Plane No. 3	S_C and S_L

Principal Stress	Plane No. 1		Plane No. 2		Plane No. 3	
S_C	....	....	....	....	....	....
S_L						
S_R						
S_S (max.) = $S_{MAX.} - S_{MIN.}$ ≦ Allow Stresss						

Application of Tables 1 and 2: The first step is to calculate and list the physical loadings and then to calculate the resultant stresses. These principal stresses are listed in Table 1. Table 2 lists the principal stress and the planes on which they act. The algebraic sum of these principal stresses for each plane is the maximum shear stress, and the largest of these three values is to be equal to less than the allowable stress.

Physical data at vessel section under consideration:

t = shell thickness —in.

D_1 = inside diameter of shell —in.

D_2 = outside diameter of shell —in.

e = longitudinal and circumferential joint efficiency

A_1 = cross-sectional area of metal in shell —sq. in.

$$= \left[\pi \times \frac{D_1 + D_2}{2}\right] t$$

A_2 = transverse surface area within outside diameter of shell —sq. in.

$$= \pi \times \left[\frac{D_2}{2}\right]^2$$

Z = section modulus of shell —in.^{3}

$$= .0982 \left[\frac{D_2^4 - D_1^4}{D_2}\right]$$

P = internal design pressure —psi.

W = weight of vessel, empty, operating, or flooded —lbs.

E = moment due to external supplementary loads —in.-lbs.

Resultant Stresses:

S_C = circumferential stress due to design pressure —psi

$$= P\left[\frac{D_1}{2} + .6t\right]/et$$

S_P = longitudinal stress due to pressure —psi

$= S_C/2$

S_W = longitudinal stress due to weight —psi

$= W/A_1$

S_E = longitudinal stress due to moment (E) —psi

$= E/Z$

S_R = radial stress due to pressure —psi

The following assumption may be made to simplify the calculation of the section modulus of the shell at a section under consideration.

$$A_2 \times t = Z$$

EXAMPLE NO. 1

Basic Design Data: Tower is self supporting (no longitudinal stiffeners or bracing)

Plate material—SA-285 Grade C, FBQ

maximum allowable stress values:

in tension—13,750 psi

in shear—11,000 psi

Design pressure	100 psi
Design temperature	650 F
Inside shell diameter	6′-0″
Corrosion allowance	⅛″
Joint efficiency	80 percent
Shell plate thickness	½″

TABLE 1A—Principal Stresses (Max. and Min.)

	Circum. Pressure Stress S_C (+)	Radial Stress S_R (±)	Longitudinal Stress $S_L = \Sigma(S_P + S_W + S_E)$			
			Pressure S_P (+)	Weight S_W (—)	External Loads S_E (±)	S_L (±)
Nearside	+12,116	0	+6,058	—362	+5,235	+10,931
Farside	+12,116	0	+6.058	—362	—5,235	+461

Weight of tower 31,000 lbs.
Longitudinal bending moment at section to be checked 8,100,000 in.-lbs.

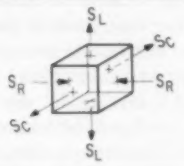
Physical data at section under consideration.

$t = .5 - .125 = .375''$ (corroded)
$P = 100$ psi
$D_1 = 72.25''$
$D_2 = 73.00''$
$W = 31{,}000$ lbs.
$E = 8{,}100{,}000$ in.-lbs.
$A_1 = 3.14 \times (72.25 + 73.00)/2 \times .375 = 85.62$ in.^{2}
$Z = 0.982 \times (73^4 - 72.25^4)/73 = 1547$ in.^{3}

Resultant Stresses:

$Sc = (100/.8 \times .375)\ (72.25/2 + .6 \times .375) = 12{,}116$ psi
$Sp = 12{,}116/2 = 6{,}058$ psi
$Sw = 31{,}000/85.62 = 362$ psi
$S_E = 8.100{,}000/1547 = 5{,}235$ psi
$S_R = 100$ psi and 0 psi

TABLE 2A—Maximum Shear Stress



Principal Plane	Principal Stress
Plane No. 1	S_L and S_R
Plane No. 2	Sc and S_R
Plane No. 3	Sc and S_L

Principal Stress	Plane No. 1		Plane No. 2		Plane No. 3	
	Nearside	Farside	Nearside	Farside	Nearside	Farside
Sc	....	....	+12,116	+12,116	+12,116	+12,116
S_L	+10,931	+461	....	....	+10,931	+461
S_R	0	0	0	0	....	....
Ss (max.) = SMAX—SMIN ≤ Allow. Stress	+10,931	+461	+12,116	+12,116	+1,185	+11,655

Summary of Results:

Nearside: Maximum stress + 12,116 psi in principal plane #2
Farside: Maximum stress + 12,116 psi in principal plane #2

For these given set of conditions, the maximum stress is 12,116 psi and is a circumferential ring stress.

EXAMPLE NO. 2

Basic Design Data: Similar to Example No. 1, except for the following data:

Weight of tower 45,000 lbs.
Longitudinal bending moment 12,000,000 in.-lbs.

Physical data at section under consideration:

$t = .375$ in.
$D_1 = 72.25$ in.
$D_2 = 73.00$ in.
$A_1 = 85.62$ sq. in.
$A_2 = 3.14 \times (73/2)^2 = 4{,}183$ sq. in.
$Z = 4{,}183 \times .375 = 1{,}568$ in.^{3}
$P = 100$ psi
$W = 45{,}000$ lbs.
$E = 12{,}000{,}000$ in.-lbs.

Resultant Stresses:

$Sc = 12{,}116$ psi
$Sp = 6{,}058$ psi
$Sw = 45{,}000/85.62 = 525$ psi
$S_E = 12{,}000{,}000/1{,}568 = 7{,}650$ psi
$S_R = 100$ psi and 0 psi

Summary of Results:

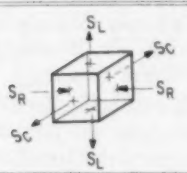
Nearside: Maximum stress + 13,183 psi in principal plane #1
Farside: Maximum stress + 14,233 psi in principal plane #3

In this example, the maximum stress is 14,233 psi and is a shear stress on the farside. The resulting stress exceeds the allowable stress for the material used. Therefore, it is necessary to increase the shell plate thickness or provide longitudinal stiffeners at the section that is overstressed.

TABLE 1B—Principal Stresses (Max. and Min.)

	Circum. Pressure Stress Sc (+)	Radial Stress S_R (±)	Longitudinal Stress $S_L = \Sigma (Sp + Sw + S_E)$			
			Pressure Sp (+)	Weight Sw (—)	External Loads S_E (±)	S_L (±)
Nearside	+12,116	0	+6,058	—525	+7,650	+13,183
Farside	+12,116	0	+6,058	—525	—7,650	—2,117

TABLE 2B—Maximum Shear Stress



Principal Plane	Principal Stress
Plane No. 1	S_L and S_R
Plane No. 2	Sc and S_R
Plane No. 3	Sc and S_L

Principal Stress	Plane No. 1		Plane No. 2		Plane No. 3	
	Nearside	Farside	Nearside	Farside	Nearside	Farside
Sc	....	....	+12,116	+12,116	+12,116	+12,116
S_L	+13,183	—2,117	....	....	+13,183	—2,117
S_R	0	0	0	0	....	....
Ss (max.) = SMAX—SMIN ≤ Allow. Stress	+13,183	—2,117	+12,116	+12,116	+1,067	+14,233

About the Author

Bernard C. Walton, a senior design engineer for Chemical Construction Corp., has been with the company since 1956. A graduate of Newark College of Engineering with a B.S. degree in mechanical engineering, Walton worked for Arthur G. McKee & Co. from 1947 to 1956 where he was supervisor of the piping stress analysis section. His present duties include design and structural stress analysis of pressure vessels, piping and various high pressure and high temperature equipment.

Know Your Asphalts—Part 12

What Causes Asphalt Failure?

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BEHAVIOR is defined as how asphalts perform in service. It comprises the question of deterioration and break-up of the bitumen, whether on road, roof, canal-lining or in any other form or state in which it has been applied. Being an organic material the service life of any bitumen is, after all, finite.

Investigations of recent years show that the failure of a bituminous film, disregarding the nature of the surface for the moment, is immediately apparent. Failure occurs when the desirable necessary physical property of the binder, originally present, has disappeared. It is immediately apparent that some change in the rheology of the asphalt has taken place. Deterioration follows under various mechanical conditions such as load, attrition of traffic, weather, etc. The immediate physical cause of deterioration in most cases is a distinct loss of adhesion by the binder.

Less apparent, however, is the underlying cause of the physical changes. Not visible are the chemical alteration of the hydrocarbon groups which make up the bitumen and cause the physical changes. The outward change in physical structure of the binder is dependent on the nature of the hydrocarbons composing the bitumen. Their structure, molecular weight and chemical considerations, such as unsaturation, sensitivity to various wavelengths in the spectrum, catalysis, etc., all enter into these chemical and more apparent physical changes.

An answer is being sought as to why some paving asphalts make poor roofing types, and again why a certain high grade roof-coating material will utterly fail when used as a paving binder. There are cases where pavements made with fluxed Gilsonite of very short ductility have given most excellent service for the past 48 years in a sub-tropical climate. Also a case, now quite renowned, where a very temperature-susceptible bitumen has shown a perfect service life of some 60 years under heavy traffic, and fairly large extreme of climatic changes. Answers to such questions and case-histories await solution from both chemist and rheologist alike.

Laboratory tests made on the bitumen extracted from pavements that have deteriorated over the years show a definite trend of physical changes. The bitumen appears to be very much different from the original material put into the paving mixture. Besides a lowering of the penetration or hardening in all cases, a marked reduction in the ductility of the bitumen has also taken place. The bitumen also appears in most cases less resilient and less adhesive. Aging occurs regardless of the construction methods, but poor construction methods have a tremendous bearing on the subject. Various types of construction also show different trends toward "break-up."

Recent investigations appear to show that bitumen oxidation is the prime underlying cause of bitumen deterioration rather than mere hardening, or loss in penetration. There is an initial hardening at the time of hot-mixing in the asphalt plant, but very little oxidation. Aged bitumens extracted from pavements often show melting points and low ductilities at 77 F, similar to that made by blowing or oxidation reactions in making roofing asphalts.

There are cases nevertheless where extracted bitumens from good performing pavements show this lowering of test values. Such sections may be quite young in service life (under 10 years) so at that time a trend as to when real break-up will occur cannot be predicted. Considerable work is going on among highway engineers in formulating modern "trend curves" and such data is most valuable when correlated with the physical studies of bitumens based on fundamental chemical considerations.

The type of traffic on roads that are down many years appears to exert a very decided and perhaps the greatest influence toward a more rapid breakup with time than other factors which actually might show a retarding effect on deterioration.

By systematic highway research which calls for employing the basic principles of physics and chemistry combined road service life should be extended to some 75 or 100 years, under the increasingly heavy traffic conditions.

It can be said of the recent rapid advances being made in new analytical techniques and asphalt testing instruments—such as the rotational and micro-viscosimeters, sonic and irradiation techniques—that they herald an era in asphalt technology that has been perhaps long overdue. This points toward greater understanding of the nature of bitumen and its wide applications. In addition to the above, investigators are concerned with the effects of ceresins present in asphalts and their relation to "structure." Also the kinetics of the oxidation of asphalts is under study. Studies are being made in Europe on the mechanism of asphalt adhesion. All of this basic research signifies the accelerated pace of asphalt studies.

Bitumens, their structure and chemical constitution, present to the versatile organic chemist his greatest challenge. The rheologist will find in asphalt one of the most ideal materials that can be selected for physico-chemical study.

These perplexing questions on the constitution and performance of asphalts will be eventually answered. New techniques and research programs will solve these problems for asphalts. We have all seen the combined efforts of many chemical research groups, working on the constitution of modern lubricating oils, develop a product that performs in a highly efficient manner.

Already new methods of asphalt synthesis, asphalt chemical reactions, and blending techniques are producing bitumens of special nature. These specialty specification products are exactly suited for definite road and engineering applications. Here, again, these materials conform to definite rheological standards.

The material which has been discussed in this series of articles is treated in much more detail in the author's book, "Asphalt," published by Reinhold Publishing Company. ##

Use This Chart for Water Content of Natural Gases

It is accurate for pressures up to 10,000 psia and temperatures from —50 to 300 F. You can correct for gravity of the gas and for the salinity if necessary.

John J. McKetta and Albert H. Wehe
Department of Chemical Engineering
The University of Texas, Austin

MANY INVESTIGATORS have studied the saturation water contents of natural gases at elevated pressures. In addition the dew point compositions have been determined for pure components such as methane[10], ethane[11], propane[4], butane [12], and others.

In Figure 1 is shown a general chart for the water content of various natural gases. This chart is based essentially on the work of Dodson and Standing[2] who worked with a natural gas with a gravity of 0.65. The chart shown in Figure 1 has been corrected to a gravity of 0.60. The extension to low temperatures was taken from the work of McCarthy, Boyd and Reid[7], who used the low temperature experimental work of Skinner.[13] On the chart in Figure 1, additional data were used from the work of Deaton and Frost[1], Hammerschmidt[3], Laulhere and Briscoe[6], and others.

Hydrate formation region. The dotted line on Figure 1 shows the hydrate formation conditions. The equilibrium at temperatures below the hydrate formation temperatures is between the gas and solid hydrate rather than the equilibrium between the gas and liquid which exists at temperatures above the hydrate formation conditions. The first to point out this discrepancy were Kobayashi and Katz.[5] There is a slight change in slope of the lines below the hydrate formation temperature, however, it is hardly noticeable.

Correction for different gravity. McKetta and Katz[9] working with the methane-butane-water system showed that the amount of water required to saturate a gas depends on the molecular weight (hence the gravity) of the gas. They were able to vary the composition of their gas mixtures so they could approximate gas gravities ranging from 0.58 to 1.9. They also incorporated the results of the methane-water system[10], ethane-water system[11] and butane-water system[12] to increase the range of gravities from 0.55 to 2.0. They showed that a correction factor for gas gravity was a function of the temperature of the gas. This correction factor is shown on Figure 1 under the title "Correction for Gas Gravity" and is called, C_G where:

$$C_G = \frac{\text{lbs. water in Gas of Gravity, G}}{\text{lbs. water in Gas of Gravity of 0.6}}$$

Correction for salinity. Dodson and Standing[2] published extensive data on natural gas-water and natural gas-brine systems. They used brines of different concentrations and were able to determine the effect of salinity on the dew point compositions of the gas. McKetta and Katz[8] also presented a correction for the salinity of the brine on the dew point compositions of the natural gas-water systems.

In Figure 1 there is a "correction chart for salinity" from which the salinity correction factor, C_S, is obtained.

$$C_S = \frac{\text{lb. water in gas if gas had been in contact with brine}}{\text{lb. water in gas if gas had been in contact with water}}$$

Sample Calculation. A natural gas, Gravity = 0.9 is in contact with brine in a reservoir. The brine contains 30,000 ppm solids (approximately 3 percent NaCl). The pressure of the gas is 3000 psia and the gas temperature is 150° F. How much water is in the gas in pounds of water per million cubic feet of gas (measured at 60° F. and 14.7 psia)?

Solution: (a) Follow dashed lines on Figure 1. From the general chart of Figure 1, at 3000 psia and 150° F. a 0.6 gravity gas would contain 105 pounds of water per million cubic feet of 0.6 gas, if the gas had been in contact with pure water.

(b) Correction for gas gravity from 0.6 to 0.9: From the "correction chart for gravity," follow the dashed line from the abscissa where the desired gravity is 0.9, vertically, to the 150° F. isotherm. Read horizontally, the C_G, correction factor for gas gravity, = 0.98.

(c) Correction for Salinity of Brine: See the second correction chart on the general Figure 1. At a brine salinity of 3% go vertically to the correction line and read on the ordinate the value of $C_S = 0.93$.

Final Answer: 105 lbs. water $\times$ C_G $\times$ C_S = 105 $\times$ 0.98 $\times$ 0.93 = 95.6 lbs. water in the gas. The experimental value for this gas was 96.2 which is within the desired accuracy.

TURN PAGE FOR CHART ►

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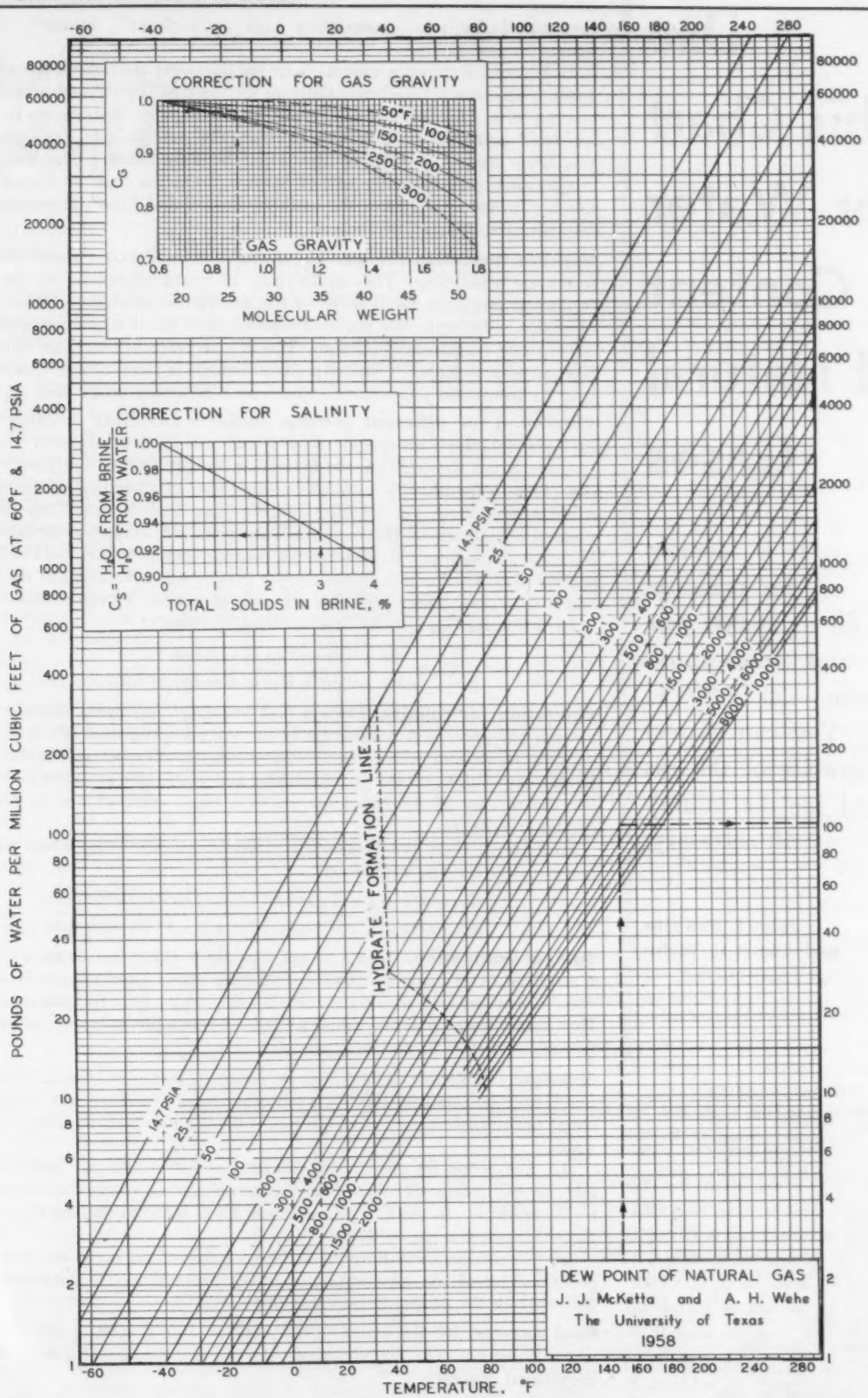


Figure 1—Water contents of natural gases with corrections for salinity and gravity.

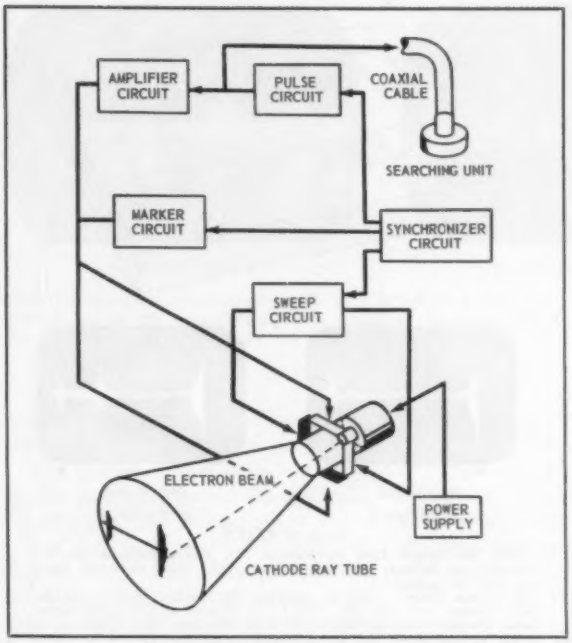


FIGURE 1—By photographing the tube, records may be maintained.

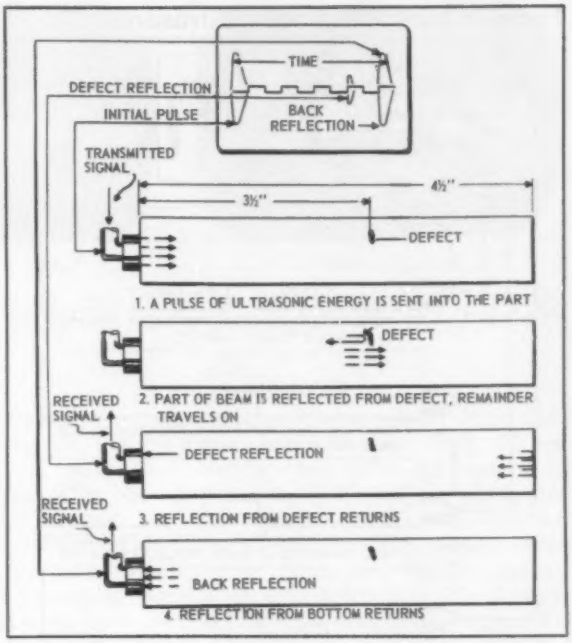


FIGURE 2—A defect is shown as a pip on the screen.

Take a look at . . .

Today's New PM Tool—Ultrasonics

Preventive maintenance is the new look for maintenance programs. The technique of ultrasonic testing allows detection and correction of defects before failure causes downtime in your process.

R. N. Hafemeister
Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

SOME OF the maintenance supervisor's daily problems may be solved by looking at the relatively new field of nondestructive testing, called ultrasonics. During the past 10 years this test method has rapidly gained popularity as being a rapid and reliable means of testing materials for possible failure. The test preparations are simple, inexpensive and do not generally require disassembly of the equipment to be tested.

Ultrasonic principles. It is well known that high frequency sound waves can be transmitted through a material by properly coupling the sound producer to the material. Also, sound waves can be reflected the same as light waves; they will travel distances of 100 feet in steel, 150 feet in aluminum and various lengths in wood, concrete or plastics. The operation of an ultrasonic test unit is illustrated by a block diagram shown in Figure 1.

A quartz crystal is vibrated by an electrical impulse and produces a sound wave of the proper frequency. The crystal, having produced a pulsed sound wave, then acts as a receiver

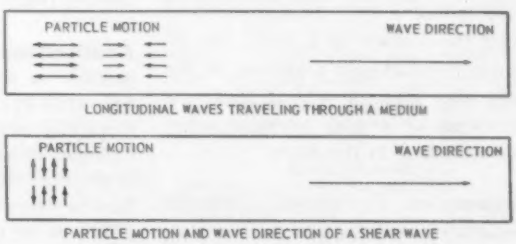


FIGURE 3—Longitudinal waves and particles both travel along the part's axis while shear waves travel through the part and particles move across the axis.

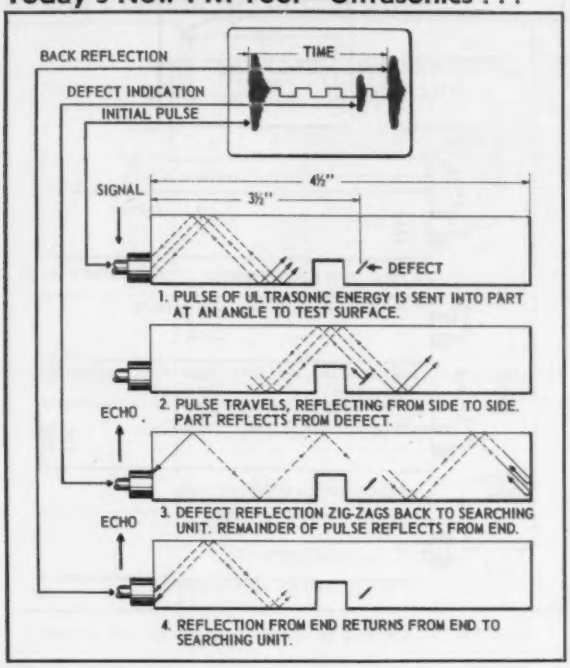

BACK REFLECTION
TIME
DEFECT INDICATION
INITIAL PULSE
SIGNAL
4½"
3½"
DEFECT
1. PULSE OF ULTRASONIC ENERGY IS SENT INTO PART AT AN ANGLE TO TEST SURFACE.
2. PULSE TRAVELS, REFLECTING FROM SIDE TO SIDE. PART REFLECTS FROM DEFECT.
ECHO
3. DEFECT REFLECTION ZIG-ZAGS BACK TO SEARCHING UNIT. REMAINDER OF PULSE REFLECTS FROM END.
ECHO
4. REFLECTION FROM END RETURNS FROM END TO SEARCHING UNIT.

FIGURE 4—Shear waves can be made to travel through the part at angles between five degrees and 85 degrees.

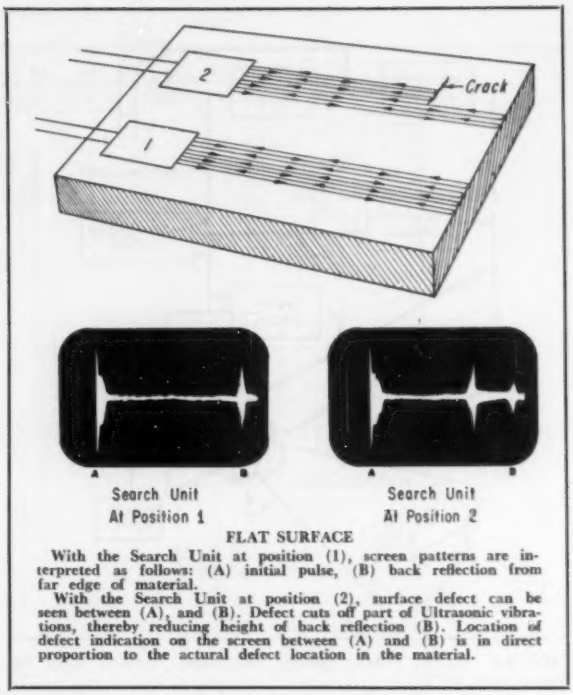

2
1
Crack
A
B
A
B
Search Unit At Position 1
Search Unit At Position 2
FLAT SURFACE
With the Search Unit at position (1), screen patterns are interpreted as follows: (A) initial pulse, (B) back reflection from far edge of material.
With the Search Unit at position (2), surface defect can be seen between (A), and (B). Defect cuts off part of Ultrasonic vibrations, thereby reducing height of back reflection (B). Location of defect indication on the screen between (A) and (B) is in direct proportion to the actural defect location in the material.

FIGURE 5—The defect appears on the screen in the same relative position it occupies between the search unit and end of test piece.

for picking up the reflected waves and changing them back to electrical impulses. Each time the sound is re-reflected, it is shown as a "pip" on the instruments' cathode ray screen (Figure 2). Linear dimensions may be obtained by being able to vary the sweep length while electronically introducing a square wave on the screen.

The normal sound wave that is produced is known as "pulsed longitudinal." A second wave known as a "shear" can also be produced (Figure 3). Shear waves usually travel at a 45-degree angle to the test face, but they can be made to travel at any angle from approximately 5 degrees to 85 degrees as shown in Figure 4. A special type of shear wave can be produced that travels parallel to the surface and at either 0.050 inches or 0.110 inches below the surface (Figure 5). One fact in connection with the surface wave that must be remembered is that it will continue to travel along the surface of a shaft, for instance, even though a portion of the shaft may have a wheel that was shrunk-on or a gear or some other item attached to the shaft.

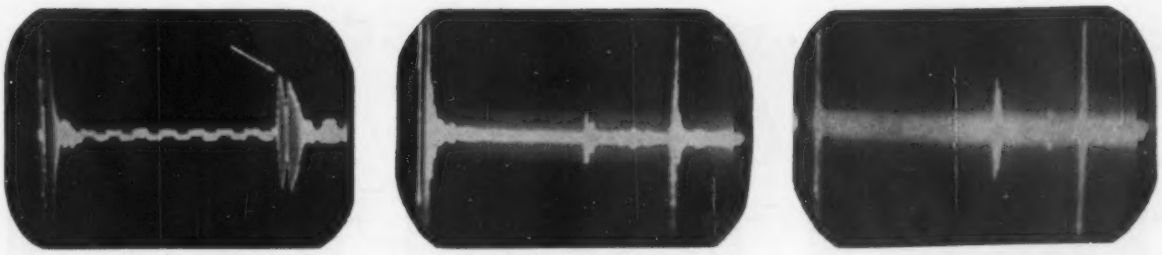
Frequencies. The normal ultrasonic frequencies used for general test purposes are 0.5, 1.0, 2.25, 5.0 and 10.0 megacycles. The basic rule is that the lower the frequency the greater the penetration and the less the sensitivity; that is, at 10.0 mc the penetration in steel might be only two feet whereas at 1.0 mc the same bar could be penetrated a distance of possibly 30 feet. However, the size of the flaw that could be detected at 1.0 mc would be much larger than that detected at 10.0 mc.

Beam angle. The crystal or search unit is normally designed as a one inch or one-half inch round or square unit. The sound leaves the crystal in a cone shaped beam. A second rule may be stated and it is that the lower the frequency the greater the cone angle. For instance, at 1.0 mc the angle is approximately 30 degrees (15 degrees from the center line); at 10-0 mc the angle is 4.5 degrees (2.25 degrees from the center line).

Applications. Using ultrasonics, it is possible to detect and penpoint not only gross voids and cracks but microscopically small defects, as well. Changes in grain size and differences in physical characteristics of materials may be observed. Wall thicknesses of pipe can be measured to the nearest 0.003 inch, and hidden linear dimensions may be measured to the nearest one-sixteenth of an inch, in many instances.

There are several types of instruments available for these applications, each of which performs a specific function. As an example, one instrument is designed primarily for the detection of flaws while another is used in thickness measurements.

Case histories. A 2,300-ton forging press, while down for repairs, was checked visually for evidence of cracks on the columns or other working parts. The four columns were approximately 40 feet long, 20 inches in diameter and threaded at both ends. A crack was observed in one of the threads approximately 30 inches from one end. The cracked column was thoroughly investigated from both ends by means of the ultrasonic test and was scrapped. Using this column as a test piece, a regular test technique was established and records made on all of the columns. Sonic tests are now made on the columns every four months and compared with the previous tests. The press is then continued in service or faulty columns replaced. By using this method, a cracked column can be detected be-



a. STUD BOLT b. SHAFT—LONG c. SHAFT—LONG

FIGURE 6—In a., the arrow points to a crack in a stud bolt. Knowledge of the exact length is necessary to determine if the first pip is a crack or an end reflection. Measurement of two shafts reveals that the middle pip in b. is a single shoulder and the double pip in the middle of c. is a double shoulder.

fore failure occurs and causes more extensive damage.

The failure of stud bolts can cause serious damage. Steam leaks, gas leaks, liquid leaks and misalignment are a few of the costly results of a stud bolt failure. Confronted with this problem, the author's company turned to sonic testing. By applying the proper technique, we determined that bolts could be tested without removing them if one face was available and that cracks could be detected in the order of 0.050 inches at the base of the thread. Several power houses, using these techniques, have instituted a regular test program to detect cracked bolts and remove them before failure occurs.

Many companies have a number of tools and test fixtures that are used exclusively to test other products beyond their rated capacity. How much damage could be done if this test fixture failed? We have set up a comprehensive test program that utilizes all of the nondestructive methods of testing. However, certain items such as shafts, couplings, bolts and flanges are sonic tested completely each time they are used and an accurate record made of the test. The record is then compared with all previous sonic test records of that piece, and they must compare exactly. With a program such as this, failure of the test fixture can be practically eliminated.

Pipes carrying corrosive substances sometimes incur dangerously thin wall thicknesses. If the reduction in wall thickness is not detected in time, costly failures result. If a test program is set up and maintained, the wall thickness can be measured and the pipe taken out of service when it approaches the danger point. The technique of pipe testing is simple but accurate. Using the known O.D. and I.D. of a particular pipe as a standard, six test blocks are made using the same O.D. but varying the I.D. by one quarter of an inch, maximum, from the standard pipe. The sonic unit is set to produce ten back reflections to a point on the screen from the standard pipe, when testing from O.D. to I.D. Without changing the instrument, the number of back reflections obtained from the other test blocks are noted. The number of back reflections are plotted on graph paper against the wall thickness. Using this graph, it is easy to determine the exact thickness of the piece under test by noting the number of back reflections and reading the thickness directly from the curve. The method is considered so reliable that we have adopted it as a standard test method.

Interpretation. This phase of ultrasonics seems to be a difficult problem with many operators. A few fundamental facts will help resolve this problem:

- The sound wave reflects from all types of surfaces whether they are round, flat, rough or smooth.
- The test will reveal all discontinuities such as grain size and all types of cracks such as slag, gas holes, non-metallic inclusion and sand pockets.
- The sound wave will reflect from fillets, counter-bores, drilled holes, threads and slots.
- Every "pip" observed on the screen must be accounted for.
- Never test a new piece without a complete sketch or drawing showing all dimensions, hidden contours and faces.

Consider carefully the last fact listed above. This is the only means of isolating all of the permanent "pips" on the screen leaving all others to be investigated and proven harmful or harmless. For example, if the drawing shows that a counter bored hole is a certain distance from the test face, this fact allows the operator to ignore the indication or "pip" made by that hole. However, the "pip" on the screen that cannot be accounted for on the drawing must be isolated as to size, direction and its relation to future use of the piece (Figure 6).

Other test methods. Other methods of nondestructive testing such as magnetic particle testing, dye penetrant and radiography should be used to complement each other. For example, if the sonic test operator discovers a defect when using a surface wave, he is faced with the problem as to whether or not the defect is a tool mark or a crack. A shallow tool mark will not show-up under the magnetic particle test or the dye penetrant test. Therefore, by using two tests to complement each other, the operator is able to ascertain the exact nature of the defect.

Records. An effective nondestructive testing program must include the compilation of accurate data and records. If no previous records exist, such a system should be started since all subsequent interpretations will be made from past records. After establishing a record file, a systematic method of repetative tests should be established.

Ultrasonic testing can be made a valuable tool in a preventative maintenance program. Two basic requisites are needed; a good records system and an unwillingness to accept this often repeated phrase, "I don't think it will work and, anyhow, why scrap it—it's run this long!"

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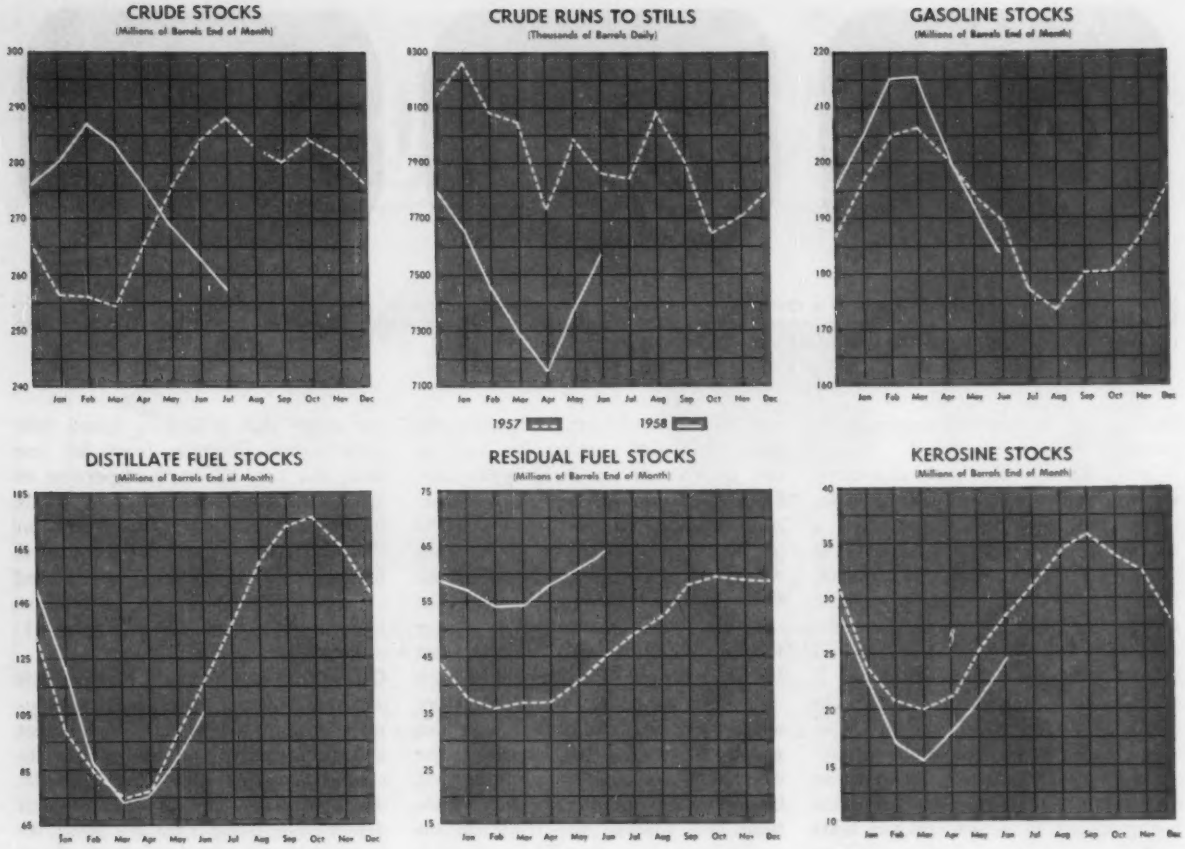


Taking Stock

- Crude stocks continue to drop
- All other stocks following seasonal trends

U. S. Monthly Oil Trends

(THOUSANDS OF BARRELS DAILY)

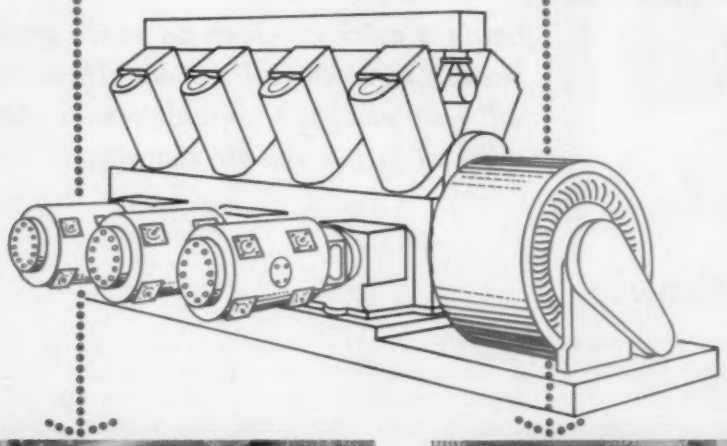
	JUNE			May	JANUARY-JUNE		
	1958	1957	% Diff.	1958	1958	1957	% Diff.
U.S. Crude Oil Production	6,335	7,107	—10.9	6,245	6,465	7,493	—13.7
U.S. Nat. Gas Liquids Prod.	750	775	— 3.2	780	787	818	— 4.7
U.S. Total Imports	1,580	1,606	— 1.6	1,484	1,598	1,505	+ 6.2
East Coast Crude Imports	700	872	—19.7	753	764	689	+10.9
Total Crude Imports	950	1,147	—17.2	936	938	920	+ 2.0
Total Refined Products	630	459	+37.3	467	646	584	+10.6
Total New Supply	8,666	9,488	— 8.7	8,510	8,850	9,816	— 9.9
Stock Changes All Oils (Daily)	+70	+1,091	.....	+129	—403	+122	.....
Total Demand All U.S. Oils	8,596	8,397	+ 2.4	8,380	9,254	9,695	— 4.6
Gasoline Demand	4,182	4,156	+ 0.6	4,075	3,813	3,878	— 1.7
Distillate Fuel Demand	1,153	1,150	+ 0.3	1,100	1,928	2,008	— 4.0
Residual Fuel Demand	1,232	1,366	— 9.8	1,150	1,503	1,720	—12.6
Domestic Demand, All Oils	8,346	7,952	+ 5.0	8,155	8,998	8,929	+ 0.8
Export Demand, All Oils	250	444	—43.7	225	256	766	—66.6
Crude Runs U.S. Refineries	7,578	7,867	— 3.7	7,397	7,117	8,002	—11.1
Domestic Crude Runs	6,601	6,757	— 2.3	6,491	6,537	7,102	— 8.0
Foreign Crude Runs	977	1,109	—11.9	906	921	900	+ 2.3

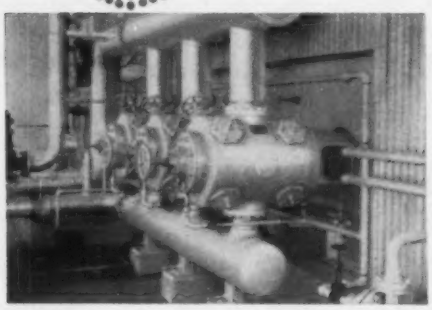
	TOTAL U.S. STOCKS Millions of Barrels End of Month				STOCKS EAST OF CALIFORNIA Millions of Barrels End of Month			
	June			May	June			May
	1958	1957	% Diff.	1958	1958	1957	% Diff.	1958
Crude Oil	257.3	284.3	— 9.5	268.8	212.4	251.4	—15.5	224.3
Gasoline	184.7	190.1	— 2.9	193.3	158.7	163.1	— 2.7	166.3
Distillate Fuel Oil	105.2	117.4	—10.4	89.3	92.1	104.6	—12.0	81.8
Residual Fuel Oil	64.3	37.8	+70.1	61.8	32.1	30.2	+ 6.3	30.7
Kerosine	24.2	28.9	—16.3	21.7	23.8	28.5	—16.5	21.3

Source: Except for latest two months, all data from U.S. Bureau of Mines. Data for last two months from American Petroleum Institute weekly reports and U.S. Bureau of Mines weekly crude stock report; except U.S. Natural Gas Liquids Production and Demand figures which are estimated by World Oil.

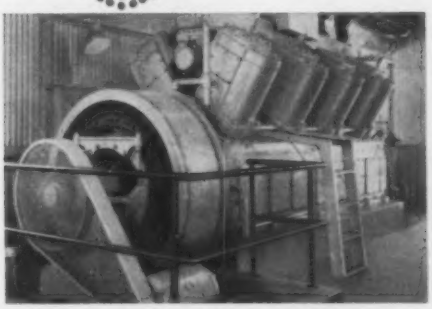
a COMPRESSOR in summer...

a GENERATOR in winter





Exterior view of compressor house at Reef Fields Gasoline Corp., Big Springs, Texas, showing compressor cylinders of the I-R gas-engine-compressor and generating unit beyond the firewall.



Interior view, showing the 275-kw generator on the I-R gas-engine-compressor and generating unit. Generator rotor provides proper flywheel effect when unit operates as compressor.

Double-Duty unit demonstrates versatility and smooth control of Ingersoll-Rand FOUR-CYCLE Gas-Engine Compressors

Why use two when one will do? The unusual combination shown above does two completely different jobs for the Reef Fields Gasoline Corp. It consists basically of an Ingersoll-Rand SVG gas-engine-compressor with an A-C generator in place of the usual flywheel.

In the summer months, this 440-hp unit is used as a refrigeration compressor. Its compressor cylinders boost propane gas to 200 psi, for use as a coolant in butane and propane recovery.

In winter when the refrigeration is not needed, the unit is put on full generator service. Its 275-kw generator alternates with four regular Ingersoll-Rand PVG gas-engine-generator units.

This double-duty application was made possible by the stability and smooth control inherent in every I-R 4-cycle, V-angle gas-engine compressor. The 4-cycle smoothness, so essential for A-C generator drive, also is important for compressor service: I-R units operate equally well from full load to no load and from full speed to half speed.

Whether you need *compression*, *generation*, or *both*, you're sure of smooth, dependable performance with an I-R gas-engine unit. Your Ingersoll-Rand representative will be glad to give you complete information and help you select the most economical unit for the job.

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4-CYCLE

COMPRESSORS • GAS & DIESEL ENGINES • PUMPS • AIR & ELECTRIC TOOLS • CONDENSERS • VACUUM EQUIPMENT • ROCK DRILLS

Valuable Reading Ahead

Here's a quick run-down on what's presented in this month's non-technical sections. These departments will keep you right up-to-date with what's new and different in this rapidly changing oil industry.

You Need to Know

Information you need to know about the companies which service and supply the oil, gas and petrochemical processing industries will be found in "What Suppliers Are Doing." This department will help you keep up with those people who serve your plant, personnel changes in their companies, and any extension of facilities or services which might benefit your operation.

Keep Going to Page 234

Octafining

This is the name given Atlantic Refining Co.'s new process, which preferentially produces only one isomer from a C_8 aromatic charge. You will learn the details on this development, plus the latest news from all over the industry when you read "What's Happening In The Industry." Simply . . .

Keep Going to Page 208

Advances in Refining

"Advances in Petroleum Chemistry and Refining," by John J. McKetta and K. A. Kobe, is the first of a series of books that will summarize and evaluate recent developments in petroleum refining and petrochemicals. This book is reviewed along with several others in this month's "Reviewing New Books"—so you may be well informed on the latest in technical material concerning the industry.

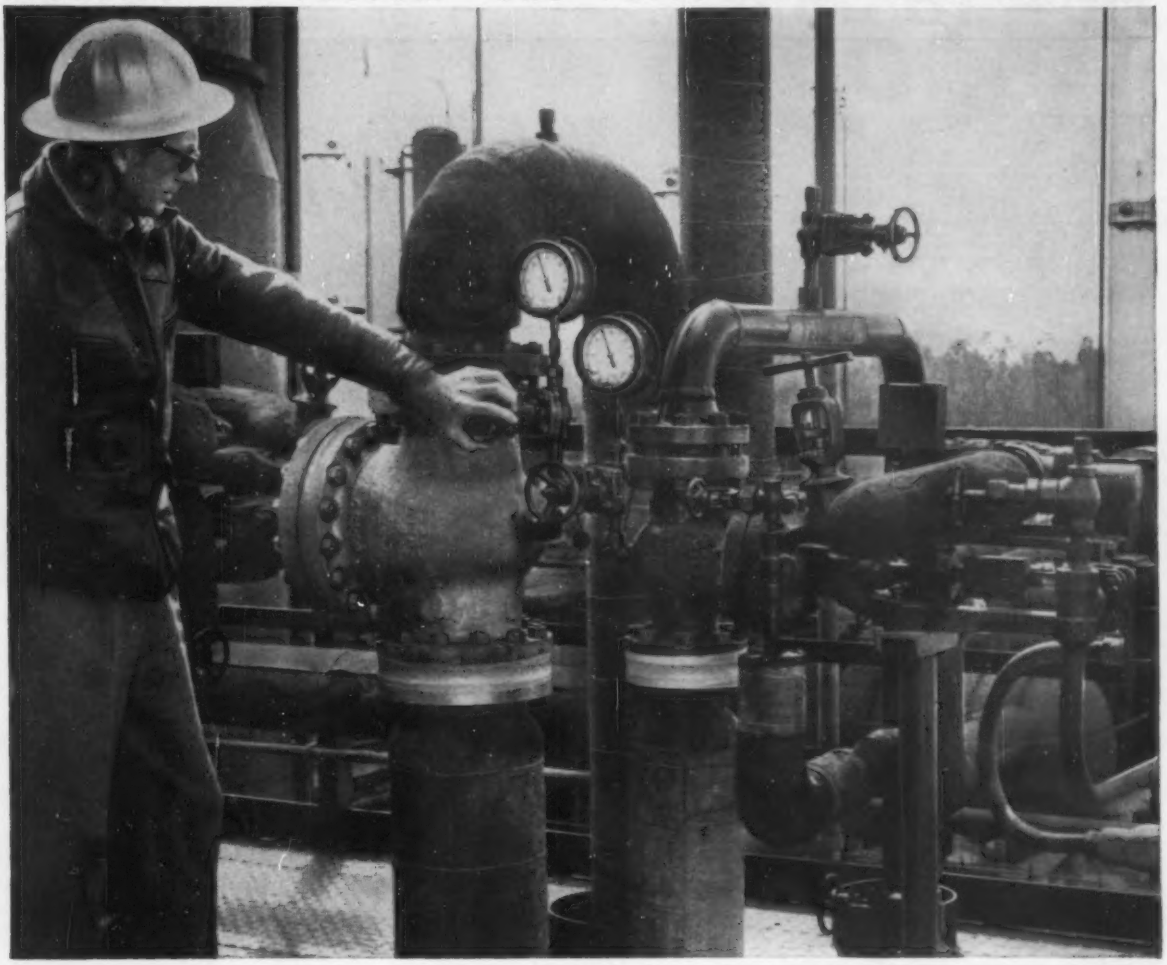
Keep Going to Page 232

A Refining Hall of Fame

Among the special features in PETROLEUM REFINER's special Oil Centennial Issue coming up in January, 1959, will be a Refining "Hall of Fame" honoring those 15 or 20 individuals who have contributed the most to the Oil, Gas and Petrochemical processing industry. We would like for each reader to submit the name of the one man he thinks has contributed the most to this industry. There are no special rules—if you think a man should be nominated, just let us know about it. All you have to do is write his name on the special postage-paid postcard just opposite page 271 of this issue. From these nominations, the final choice will be made for the Refining "Hall of Fame."

Keep Going to Page 271

Pressure vs. vacuum—one valve holds both in line



Gauge test of Crane flexible wedge disc gate valve shows no leakage around disc.

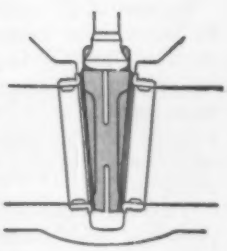
How one CRANE valve controls two-fluid process

To prevent intermixing of steam and very light hydrocarbon in a butadiene production process, the Texas Butadiene & Chemical Corp., Channelview, Tex., uses only one valve. This is unusual; the old method of double blocking required two valves.

The single valve being used is a Crane flexible wedge disc gate. In the operating cycle, this 6-inch, 400-pound air-cylinder operated valve opens or closes every seven to nine minutes. In closed position, one side of the disc holds steam at 20 psi. The other side holds light hydrocarbon at 24 inches mercury vacuum.

This dual service, combined with constant cycling, is beyond an ordinary wedge gate or plug type valve. But not beyond the Crane flexible wedge disc! It has prevented leakage and product contamination month after month on this tough service.

For full information about the efficiency and obvious economies of using Crane flexible wedge disc gate valves, see your Crane Representative or write to address below.



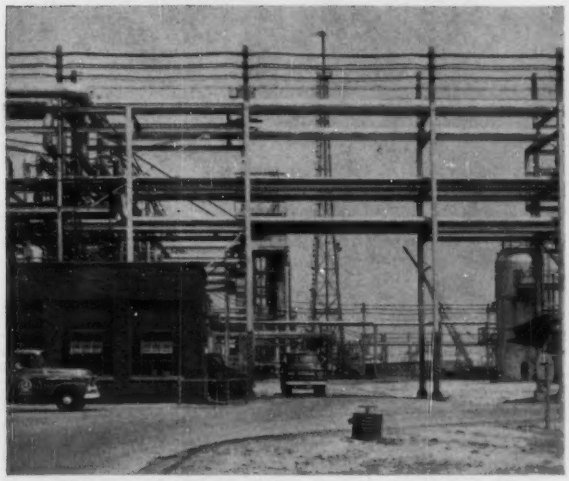
Positive wedging principle of Crane flexible wedge disc gate valve.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

Since 1855—Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas

How To Do It . . .



A mirror (under arrow, lower right) stops blind corners.

Here's what an approaching driver sees.

Make Blind Corners Safe With Mirrors

In a refinery, a traffic collision could cause more serious damage than a highway accident, for traffic at the refinery is made up largely of trucks carrying acids and petroleum products. Thus, there is the added danger of explosion and fire.

Because of this added danger, traffic safety is of extreme importance. At The Ohio Oil Company's Robinson refinery, two large convex mirrors were installed at "blind" corners, decreasing the chances of collisions where poor visibility might cause an accident.

The convex mirrors give drivers, approaching from either direction from which direct vision is limited, an enlarged view; for the curved surface of the mirror enlarges the reflection of the street area which cannot be seen directly.

The mirrors, 36 inches in diameter, are located at two dangerous intersections in the refinery. Thus, the all-weather mirrors have definitely proved to be useful traffic safety devices since their installation more than a year ago. The mirrors, like many other items of Ohio's safety equipment, are an additional safeguard and another contributor to their protection against injury and loss of life.

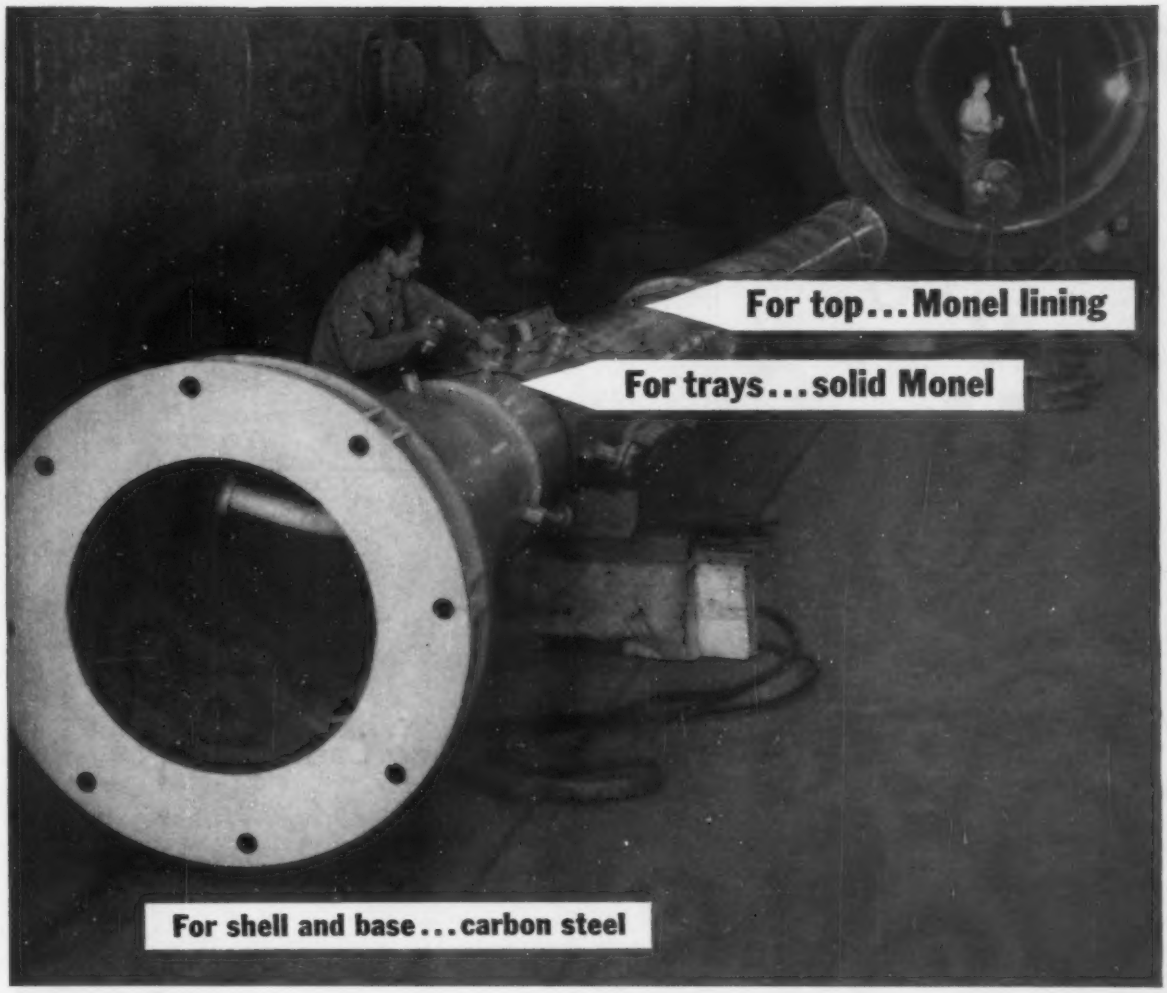
This idea is from an item in The Beacon, a publication of The Ohio Oil Company.

Hand Spray Gun Works On Small Paint Jobs →

Where it is necessary to keep machinery along the coastal areas continually painted, a quick way to paint on short jobs may be obtained by means of an insect spray gun. The paint is mixed the same as for use in regular spray guns and placed in the insecticide container. The gun is screwed on the top and when the plunger is operated, paint comes out instead of insecticide.

Where greasy equipment is to be cleaned and painted, a solvent or paint remover may be first placed in the gun and sprayed on the equipment to clean it thoroughly. Where the coat is thick, several applications of the solvent may have to be made, using gasoline for the last run. After the equipment is perfectly clean, the paint is placed in the insect spray gun and one or more coats applied.

This item was submitted by Harry Hess, Wichita, Kan.



How to put tower corrosion on a "starvation diet"

Tower-top corrosion won't cause trouble in the fractionating tower shown above.

The builder of this tower, Fritz W. Glitsch & Sons, working closely with the refiner and Inco's Corrosion Engineering Section, put corrosion on a "starvation diet" of Monel* nickel-copper alloy.

They put Monel alloy at the trouble spots. Above the probable dew line (the top 15 feet, 6 inches) a 3/32-inch Monel alloy lining was used. For the trays, where agitation could intensify corrosion, a special design was employed in solid Monel alloy.

This is only one case... but it's typical of the way engineers are putting Monel nickel-copper alloy to work to resist tower corrosion by dilute hydrochloric acid and corrosive salts, at temperatures up to 500°F.

How is your tower down-time record? If it's not what it should be and tower-top corrosion is the cause, look into the possibilities of Monel alloy construction. Write Inco's Corrosion Engineering Section. Make the solution of your corrosion problem a team effort. *Registered trademark

The INTERNATIONAL NICKEL COMPANY, Inc.

67 Wall Street INCO New York 5, N.Y.

INCO NICKEL ALLOYS

NICKEL ALLOYS PERFORM BETTER LONGER

For more data on advertised products, use Readers' Service Cards, last page.

LOW db with JZ QUIET BURNERS

Any acceptable db level can be reached with John Zink Burner Mutes. The John Zink line includes over 50 gas, oil and combination gas and oil burners for process application. Where noise is a problem, these burners are equipped with John Zink Burner Mutes, the most efficient means of lessening primary and secondary air noise.

The John Zink Company is famous for *workable* solutions to special burner problems. Outstanding research and testing facilities assure perfect on-the-job performance for all new designs.

JOHN ZINK
COMPANY
INDUSTRIAL BURNERS / AIR HEATERS / DISPOSAL UNITS
INERT GAS GENERATORS

4401 S. PEORIA
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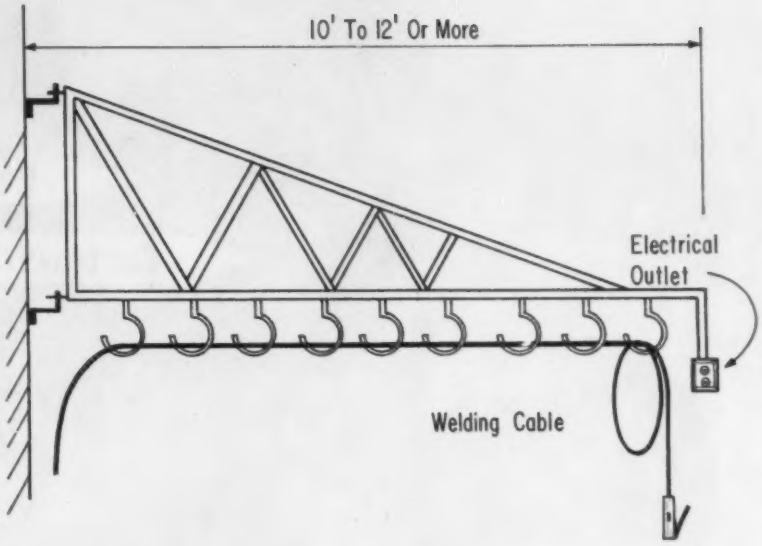
How to Do It...

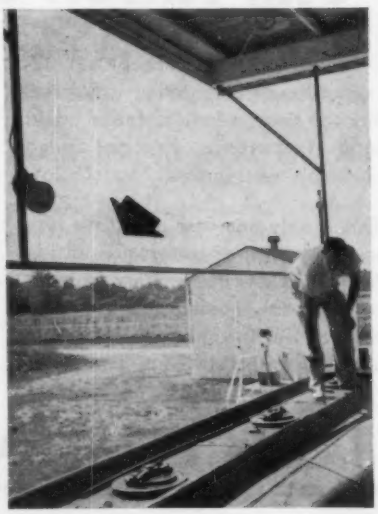


Boom Keeps Welding Cable Off Floor

A maintenance shop can easily become a cluttered place. Lengths of welding cable scattered on the floor not only add to the clutter but present a safety hazard. Placing the cable on an overhead boom is an ideal solution, since it gets the cable off of the floor and at the same time allows it to be swung out of the way for operation of an overhead crane.

The boom can be made from half inch pipe and fastened by brackets to a wall or column. The hooks are made from bar stock and welded to the pipe for cable support. An electrical outlet completes the picture of an idea that makes shop work faster and safer.

This idea was submitted by Jack O. Evans of E. I. du Pont de Nemours & Co., Inc., Victoria, Texas.



Dog Leash Makes Handy Ground for Truck Loading

Where trucks are to be grounded at the refinery loading terminal, a handy way to keep the ground wire out of the way when the trucks are not in, is to use a dog leash with a retractable reel so that the wire winds itself up when not in use. First the reel is taken apart so that it makes a good connection, whether it is extended or retracted, then it is fastened solidly at a convenient place for the loader. A metal clip is installed on the end, and when the trucks come in, it is a simple matter to unwind the reel and attach the ground cable

For more data on advertised products, use Readers' Service Cards, last page.

THIS MAN CAN ADD TO YOUR PROFIT PICTURE. This is a Dowell service engineer—on the job. His knowledge and abilities in chemical cleaning can help you to greater profits. Recently, an eastern corporation used Dowell Service for its boiler cleaning maintenance. Dowell's service engineer studied the problem, did the job. His use of chemical solvents in cleaning tubes and other metal surfaces was effective. On the basis of Dowell Service, this company will realize improved profits of $440,000.

There are three ways you can clean your plant equipment: *Mechanically* with your own crews—inefficient, time consuming and expensive in today's industrial pace. *Chemically* with your own crews—again inefficient and unprofitable because of heavy payroll and the personnel's lack of qualification. Or with *Dowell Service,* the modern chemical cleaning method.

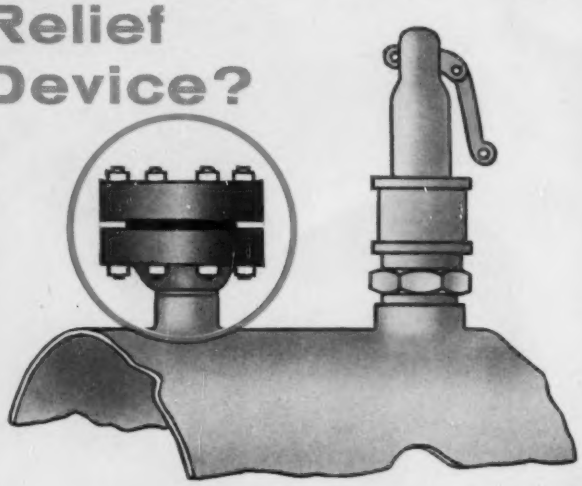
With Dowell Service you receive the benefits of more than fifteen years experience in chemical cleaning—plus special equipment, chemicals, research and trained personnel. You pay one charge, get an efficient job, handled by knowledgeable people.

Every industry can profit from Dowell Service. Ask your maintenance and operating engineers if they have thoroughly investigated the profit possibilities of using Dowell Service. DOWELL—A SERVICE DIVISION OF THE DOW CHEMICAL COMPANY. Headquarters and research center, Tulsa 1, Oklahoma; 165 offices and stations to serve you.

Chemical cleaning service for industry DOWELL

For more data on advertised products, use Readers' Service Cards, last page.

Why The "Standby" Relief Device?



The BS&B *Safety Head* Takes Over Under Abnormal Conditions

Your relief valve may need a helping hand.
The double protection provided by this relief valve–BS&B Safety Head combination is ideal when—

- **The nature of the pressurized fluid may cause malfunction of relief valve.**
- **Instantaneous over-pressure occurs due to abnormal heat or regulating conditions.**

When pressure-relief requirement is greater than the discharge capacity of the valve, the BS&B Safety Head provides an instantaneous, unrestricted opening.

Thousands of pressure systems are now protected with the added security of BS&B Safety Heads.

BS&B Engineers will be glad to evaluate your pressure system for application of the correct BS&B Safety Head.

OVER 60 YEARS BS&B RELIABILITY — ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

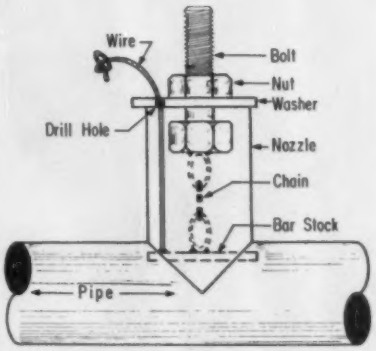
Write, Wire or Phone...

BLACK, SIVALLS & BRYSON, INC.
Safety Head Division, Dept. 2-F8
7500 East 12th Street
Kansas City 26, Missouri
Telephone: BEnton 1-7200

How to Do It...

before the filler caps are removed. When the truck has been filled, the cable is unsnapped and retracts itself instantly.

This idea was submitted by Harry Hess of Wichita, Kansas.



One Man Can Position Nozzle Firmly for Welding

A welder without a helper has his hands full in trying to fasten a nozzle to a pipe before welding. One way to simplify the procedure is to weld a short length of chain to a bolt head and a piece of bar stock, as shown in the drawing. By tightening down on the nut, the nozzle can be positioned for welding.

A wire is tacked to the bar stock and is pulled through a hole drilled in the washer. To remove, simply loosen the nut, drop the assembly into the pipe and pull on the wire (in order to straighten the bar stock for removal).

One man can position the nozzle quickly and accurately in any position, and have a steady piece of work to weld.

This idea was submitted by J. Keingen of Rotterdam, Holland.

YOUR IDEAS ARE VALUABLE!

At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Petroleum Refiner*, P. O. Box 2608, Houston.

For more data on advertised products, use Readers' Service Cards, last page.

McKee completes America's Newest Ultraformer for Standard Oil Company (Indiana)

THIS 21,000 BSD Ultraformer Unit at Whiting, Indiana went on stream on June 25th—less than a year from the time ground was broken.

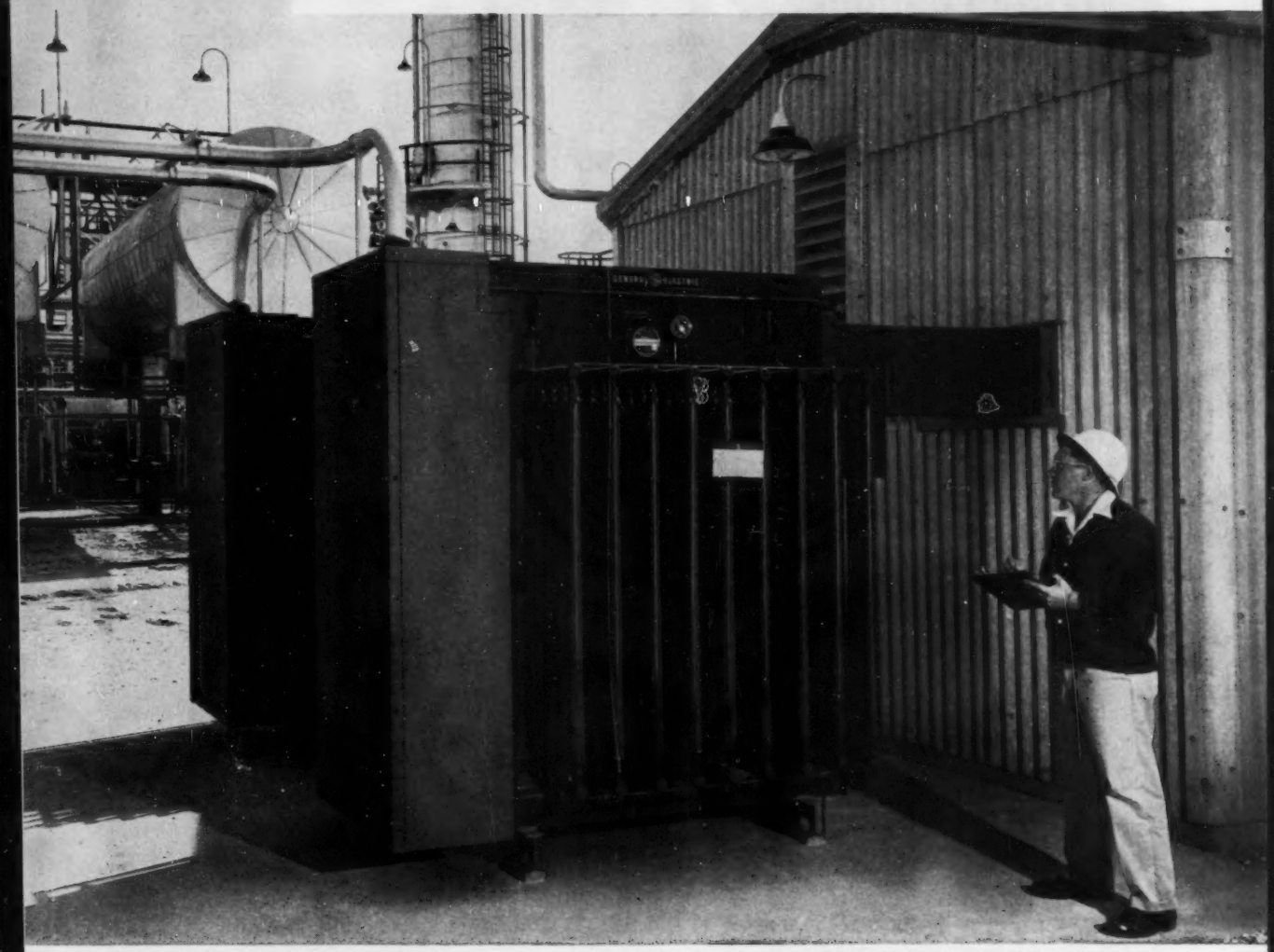
Many innovations in design and construction make this large processing unit an outstanding example of modern engineering by McKee. Designed and built under a single lump-sum contract, it meets today's processing-plant requirements for high quality engineering, sound, economical construction and fast completion.

The new Ultraformer typifies the results you can expect when you call in McKee.

McKee
ENGINEERING & CONSTRUCTION
Services

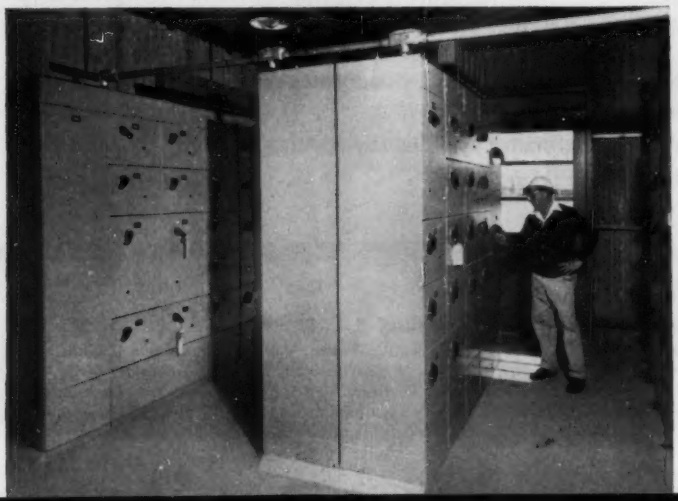
Arthur G. McKee & Company • Engineers and Contractors
Headquarters: McKee Building • 2300 Chester Avenue • Cleveland 1, Ohio
Offices: New York, N. Y. • Union, N. J. • Houston, Tex. • Washington, D. C.
British Representatives of Metals Division: Head, Wrightson & Co., Limited
Canada: Arthur G. McKee & Company of Canada, Ltd., 372 Bay St., Toronto

At W. R. Grace and Company's new polyolefin plant . . .



RELIABLE G-E TRANSFORMERS are easy to install, easy to maintain. Transformers pictured are rated 1,000-KVA.

PRE-ASSEMBLED, PACKAGED nature of General Electric motor-control centers greatly reduced installation costs at new Grace & Co. polyolefin plant. Equipment costs were less because remotely located centers did not require extra-protected equipment.



RELIABLE, LONG LIFE General Electric 150-hp induction motors drive extruders which compress GREX† pellets in their final form.

† Registered Trade-mark of W. R. Grace & Co.

Standardization on General Electric equipment cut spare parts inventory by 60%

OPERATION upturn — Buy now for extra values — GENERAL ELECTRIC

Here's how single-source purchasing and expert system-engineering assistance cut installation time and costs, and saved valuable floor space for the Polymer Chemicals Division of W. R. Grace and Company.

Because standardization on General Electric motors, controls and switchgear permitted maximum parts interchangeability, W. R. Grace and Company reduced anticipated spare parts inventories by 60 per cent at their new Baton Rouge polyolefin plant. Now, spare parts for their entire electrical system occupy less than 1 per cent of their warehouse area, making valuable space available for production items.

In addition, G-E engineering know-how and system-engineered electrical products helped cut installation time and costs at this new 50 million pound petrochemical facility.

Unit responsibility is the key to these major reductions. Because of the many and varied applications in this plant, W. R. Grace & Co. officials felt that standardization on one supplier was the most efficient and economical way to do the job. Previous experience with G-E equipment and technical assistance encouraged their choice of General Electric.

The pre-assembled, complete-packaged nature of G-E substations, switchgear and motor-control centers greatly reduced installation costs at this W. R. Grace & Co. plant. The remote location of the control equipment—made possible by the principle of the motor-control center—eliminated the need for expensive, specially-protected equipment.

Over 300 rugged G-E induction motors, ranging from fractionals to 150-hp, are spotted throughout the 30-acre site to provide the power required to keep the plant running 24 hours-a-day. These extra-protected motors drive pumps, agitators, extruders, mixers, conveyors and rotary valves. Built for longer life, even under tough refinery conditions, these G-E motors require less maintenance, keep downtime to a minimum.

If you plan to build a new plant, or expand your present facilities, General Electric offers the system-engineered equipment and the technical assistance to provide you with an economical, efficient electrical system. Contact your nearest General Electric Apparatus Sales Office for complete information. General Electric Company, Schenectady 5, New York.

681-16

Engineered Electrical Systems for the Petrochemical Industry

GENERAL ELECTRIC

FOR GREATER MAINTENANCE FLEXIBILITY, G-E AK-25 air circuit breakers can shut off small parts of plant when repairmen are at work. 1200-amp breakers are also used as large motor starters.

RUGGED TOTALLY-ENCLOSED and explosion-proof G-E Tri-Clad* '55' motors provide extra protection and greater safety required for some refinery applications. More reliable Tri-Clad motors require less maintenance, reduce system shutdowns. *Reg. Trade-mark of General Electric Co.

Who's Building . . .

Cosden Has New Polystyrene Plant

Big Spring plant produces polystyrene pellets in a chain of processes starting with crude oil

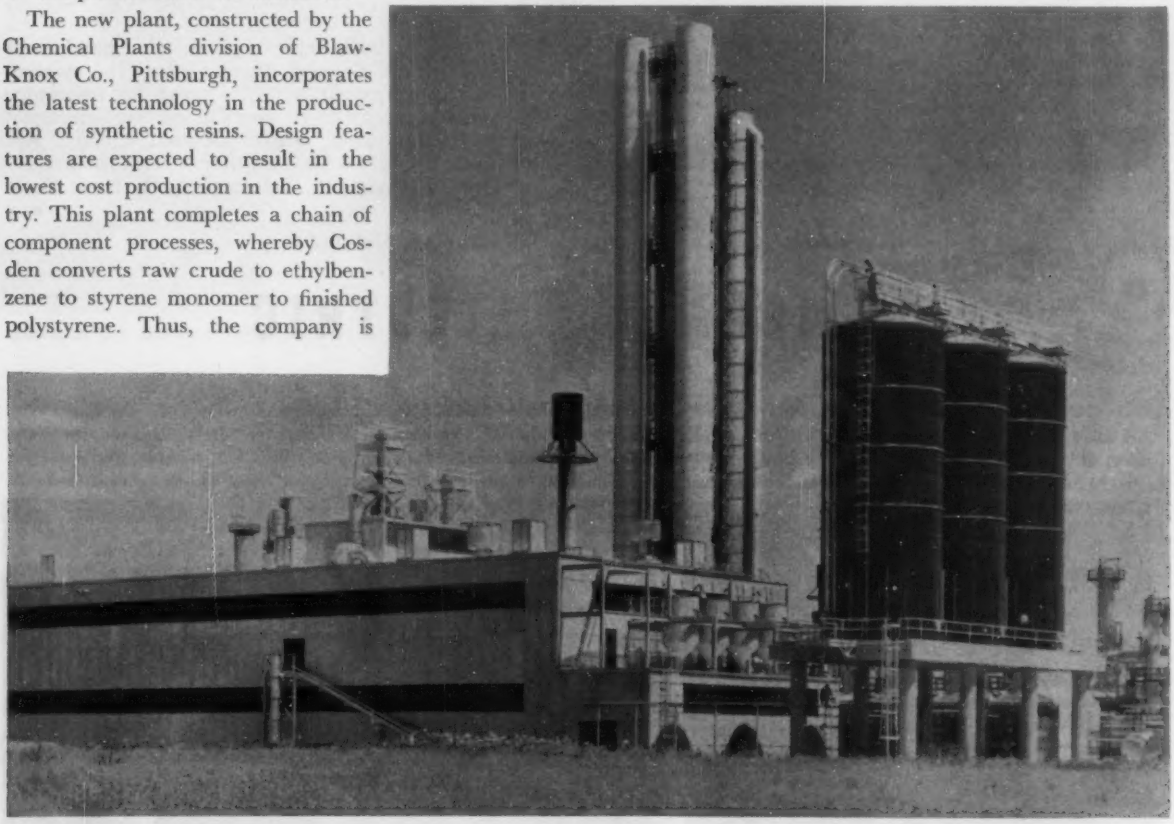
With the completion this month of a new polystyrene plant, Cosden Petroleum Corp., Big Spring, Texas, becomes one of the first to integrate all phases in manufacturing this basic material for many of today's plastic products. In announcing the final link for producing polystyrene pellets from crude oil, company officials also revealed a unique marketing plan, which would use special highway transports to deliver bulk quantities of the pellets direct to customers.

The new plant, constructed by the Chemical Plants division of Blaw-Knox Co., Pittsburgh, incorporates the latest technology in the production of synthetic resins. Design features are expected to result in the lowest cost production in the industry. This plant completes a chain of component processes, whereby Cosden converts raw crude to ethylbenzene to styrene monomer to finished polystyrene. Thus, the company is able to control product quality from first step to last.

According to the company, the new delivery concept is expected to arouse considerable interest throughout the plastics industry. Cosden trucks with a 34,000-lb. load capacity will deliver bulk quantities to gravity-feed hoppers at the customers' plants. The transport trucks are specially equipped with fast pneumatic-unloading devices. The storage hoppers permit customers to take instant inventory and eliminate such fringe expenses as unloading, warehousing, multiple handling and contamination. Bulk prices are determined on a delivery zone basis.

Only two grades of polystyrene will be produced, general purpose crystal polystyrene and high impact polystyrene.

For the styrene monomer used in



Cosdens Big Spring plant converts raw crude stepwise to ethylbenzene, styrene monomer and then finished polystyrene.

CASING AND DIAPHRAGMS—heavy construction—split horizontally for easy accessibility
EXTERNAL BEARINGS—preventing contact with gas handled
DIFFUSERS—streamlined for efficient gas handling
WELDED, CLOSED IMPELLERS—smooth continuous surfaces prevent "build-up" and resulting unbalance
SHAFT THRUST COLLAR—Kingsbury type thrust bearing to absorb load in either direction
LABYRINTH SEAL—prevents interstage leakage

DEPENDABILITY

at the heart of
your refinery when

ELLIOTT CENTRIFUGAL COMPRESSORS are in service!

Two of three Elliott motor-driven single-stage centrifugal compressors serving oil black plants in Oklahoma. Each compressor is rated 5255 inlet cfm, handling air at atmospheric pressure and boosting it to 3.85 psig.

Elliott centrifugal compressors are designed and built with the simplicity and ruggedness that pays off in *dependable,* long-term, non-stop performance. Available in single and multistage types . . . for inlet capacities up to 150,000 cfm and pressures up to about 500 psig equivalent air pressure . . . turbine or motor driven . . . with or without step-up gear. For further details, call your nearby Elliott District Office or write Elliott Company, Compressor Department, Jeannette, Pa.

ELLIOTT Company

P7-3

For more data on advertised products, use Readers' Service Cards, last page.

manufacturing polystrene, Cosden operates an adjacent plant completed in 1957. This plant recovers ethylbenzene directly from a mixed-xylene stream for conversion into commercial quantities of styrene.

Both styrene and polystyrene plants are part of a continuing program of diversification and expansion in manufacturing petro-chemicals and finished petroleum products. Hub of the program is Cosden's 32,000 bpd custom refinery at Big Spring.

Union Oil Co. of Calif.'s 100-bpd experimental plant, for the extraction of heavy oil from a large deposit of tar sand, is nearing completion in Santa Barbara County, Calif. Initial start-up of some of the units is now underway.

Purpose of the plant is to demonstrate the feasibility of profitable extraction of oil from the tar sands based on earlier research, which evolved what appears to be a simple, cheap method of extraction involving the use of water, solvents and detergents, according to the company.

Last year the company announced that if the initial pilot plant proved unsuccessful, plans would be made for an eventual larger plant of from 5,000 to 10,000 bpd capacity.

To be known as the Sisquoc Tar Sand experimental plant, the unit will have as its source of material a huge deposit of tar sand containing an estimated 50 million barrels of oil.

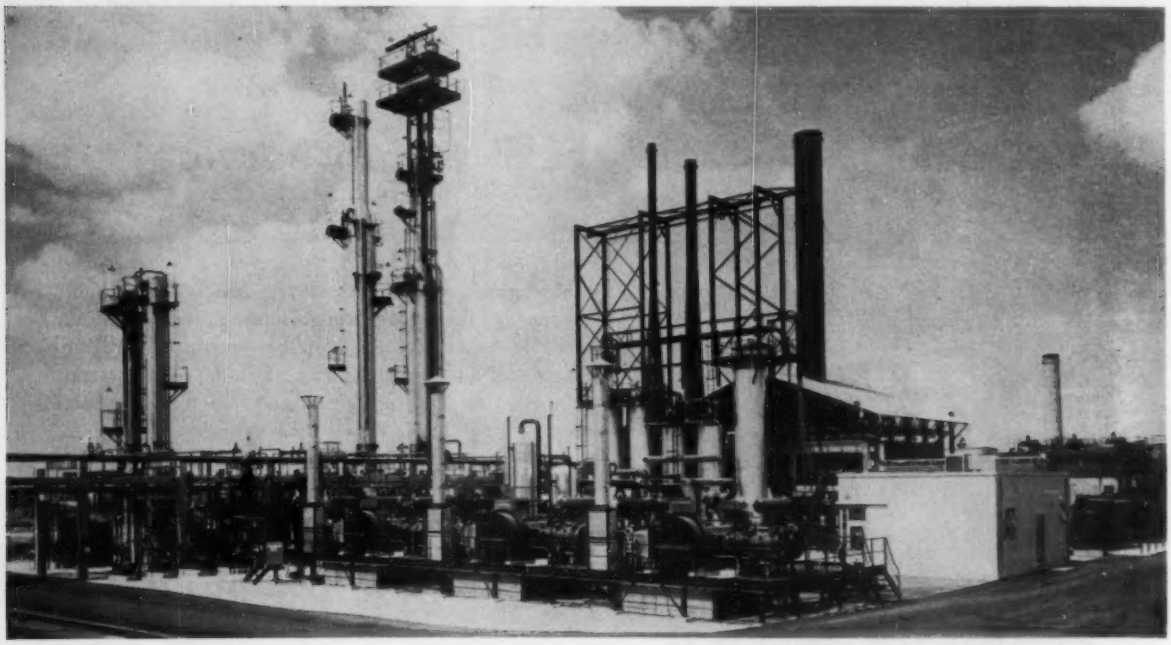
Gulf's second Port Arthur cat reformer will have 26,000 bpd capacity.

Gulf Has New Cat Reformer at Port Arthur

Gulf Oil Corp. has announced the full operation of its new 26,000-bpd catalytic reformer at its Port Arthur, Texas, refinery. This is the second such unit now in operation at Port Arthur, the first being completed in 1955 with a rated capacity of 29,000 bpd. The product from this new facility will go into motor gasoline.

The process is licensed by the Universal Oil Products Co., and Procon, Inc. was the prime contractor.

The feedstock is charged to a prefractionator tower where a naphtha side stream is taken off, mixed with a hydrogen-rich gas and heated to about 600 F. It is then charged to a Hydrobon reactor from which it passes to a high and low pressure separator. It then goes to a stripper where the hydrogen sulfide gas is removed. The



This 5,000-bpd catalytic reformer is included in Standard Oil Co. of Calif.'s modernization program at Bakersfield.

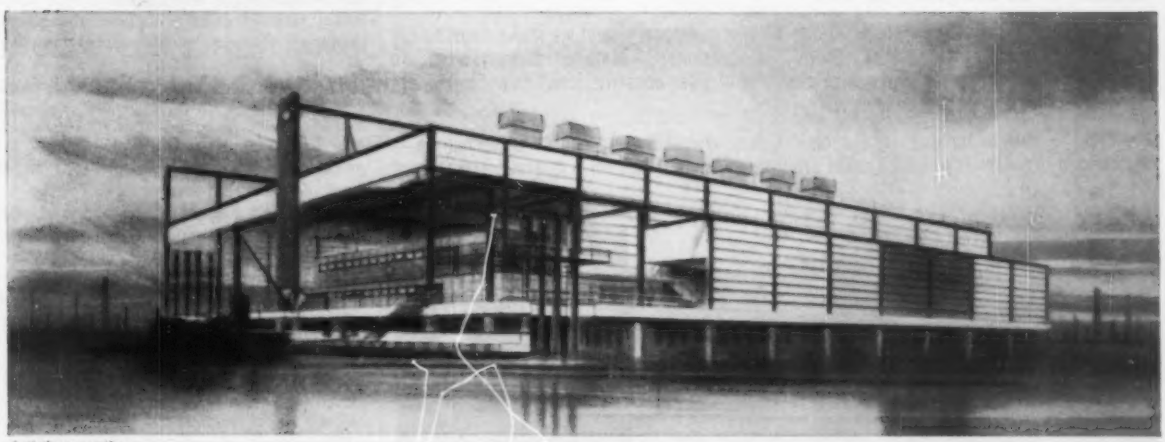
LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

385 Madison Avenue New York 17, N. Y.

Lummus Designing and Engineering Gas Conservation Plant on Lake Maracaibo for Compania Shell de Venezuela

New Plant to Play Important Role in Crude Production Program and Gas Conservation



Artist's conception

The Lummus Company is designing a 200 million cubic foot/day gas conservation plant for Compania Shell de Venezuela on Lake Maracaibo near Laguinallas.

The new plant will reinject, at high pressures, gases which have been released during the production of crude.

The gas will be conducted from the gathering stations through a network of large pipelines, as large as 30" diameter, laid on the bottom of the lake to the reinjection plant. There, using local gas as fuel, the gas is compressed by 7 gas turbine driven compressors, having a total of 56,000 HP. The high pressure gas is then returned to the oil field by pipelines on the bottom of the lake.

The plant will be constructed on a 150' x 250' platform 15 feet above the lake level, supported by approximately 250 reinforced concrete piles. The plant's tropical architecture will conform to the styling of the locale and will include modern lockers, change rooms and canteen.

Lummus is employing the most modern techniques in automatic controls and safety practices in the plant plans. Special efforts are being made to soundproof and air condition the control rooms and operating offices to afford optimum working conditions. Modern safety techniques are being used to detect gas leaks anywhere on the platform to insure overall safety for operating personnel.

Lummus has over 50 years experience in the design and construction of more than 800 plants for the process industries throughout the world. If you have a project in mind, we will be glad to discuss it with you.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y., Houston, Chicago, Washington, D. C., Montreal, London, Paris, The Hague, Caracas, Maracaibo. *Engineering Development Center:* Newark, N. J.

Astringents don't bother these gaskets—neither do contaminants, shocks or vibrations. In short, Metallo has the answer to your gasket problems in a nutshell — or on a flatcar — depending on the size gasket you need.

Metallo makes gaskets so small, 5000 can fit in a teaspoon — and we make them so big that the railroads must ship them in sections. Metallo makes standard gaskets in 22 most popular styles with a variety of filler constructions* to accommodate your most complex sealing difficulty.

One thing is sure — for quality, economy, safety, durability and superb performance — Metallo has the answer to your gasket problems. Why not call for a quotation right now!

IMMEDIATE DELIVERY FROM STOCK
CUSTOM ORDERS GIVEN PROMPT ATTENTION

RASCHIG and LESSIG RINGS
For both ordinary and difficult extraction processes in production of acids, oils and dyes, Metallo Raschig and Lessig Rings are today proving unusually satisfactory as tower packings. They are materially decreasing operating and production costs on a wide variety of reaction and scrubbing towers, rectifying columns, extraction systems and other industrial processes.
metallo

*No. 2300 is a special composition filler that is now available for use up to temperatures of +2300°F. with suitable Metallo metal jackets.

GET THE FACTS—
Write to Dept. PR-2 for new 20-page 2-color catalog.

SEE OUR CATALOG IN SWEETS PLANT ENGINEERING FILE #2J-ME or IN THE REFINERY CATALOG.

metallo gasket co.

17 BETHANY STREET • NEW BRUNSWICK, N. J. • Kilmer 5-7223

Who's Building. . .

stripper bottoms are mixed with hydrogen, heated to 900 F. or more, and then the naphtha passes into a series of three reactors where the actual reforming takes place in the presence of a platinum-containing catalyst. The resulting gasoline vapors are liquefied and passed through a separator to remove recycle gas (mostly hydrogen) for recirculation in the process and for use in the Hydrobon section. The liquid from the separator goes through a depropanizer, a debutanizer, and then a depentanizer to remove lighter hydrocarbons, leaving high octane gasoline blending stock as a liquid.

The new unit is painted in pastel colors, the first Port Arthur installation to receive this treatment. In addition to the two catalytic reformers at Port Arthur, the company has one each at its Cincinnati and Toledo refineries and three at its Philadelphia refinery. These seven units are a part of the company's over-all refinery modernization and product improvement program.

La Gloria Oil and Gas Co. has a multi-million dollar modernization program now underway at the company's Tyler, Texas, refinery.

The program is being concentrated on two units of the refinery. In about five months, when the program is completed, the refinery's gas concentration and catalytic cracking units will have undergone extensive changes, according to the company.

Increasing the capacity of charge stock will step up output from the catalytic cracking unit by some 20 to 25 percent. The gas concentration unit will have its propane and propylene recovery boosted from 55 to 92 percent.

Brown and Root, of Houston, in charge of the entire program, has the modernization work well under way.

The catalytic cracking unit has been burning approximately 7,200 pounds of petroleum coke per hour during its normal cycle of operation with a combined feed to the unit of 10,000 barrels per day. When renovation of the cat unit is completed, coke burning capacity will be increased approximately 37 percent to some 9,850 pounds of coke per hour and the combined feed to the unit will be increased to about 50 percent to 15,000 bpd. The fractionated output of the unit will then be increased by some 210 barrels per hour.

Changes in the cracking unit will include new top and bottom grids for air circulation. The side stripper or spent catalyst stripper will be reworked to improve the efficiency of catalyst recovery, and operating pressures in the unit will be upped from 17 to 28 pounds per square inch.

Other major changes to be made will include an increase in the size of the riser line and installation of another main air blower to feed air into the cracking unit.

Operating efficiency of the fractionating system of the catalytic cracking unit will be improved by the installation of new trays in the fractionating tower.

Primary work on the gas absorption section will consist of replacing certain equip-

For more data on advertised products, use Readers' Service Cards, last page.

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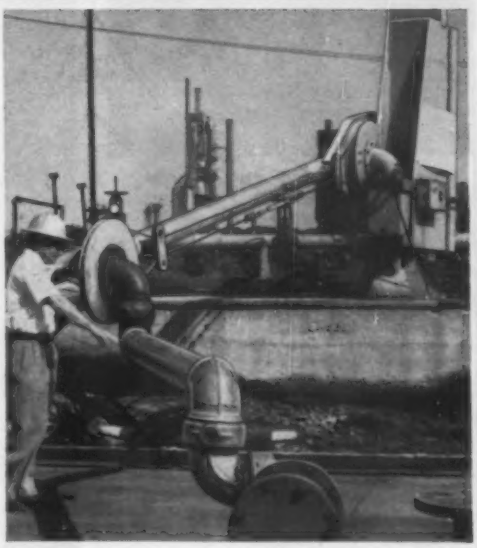

The Chiksan Barge Loading Arm is designed to reach approximately 20 feet from dock riser to barge flange. Total length of Arm is 25 feet.

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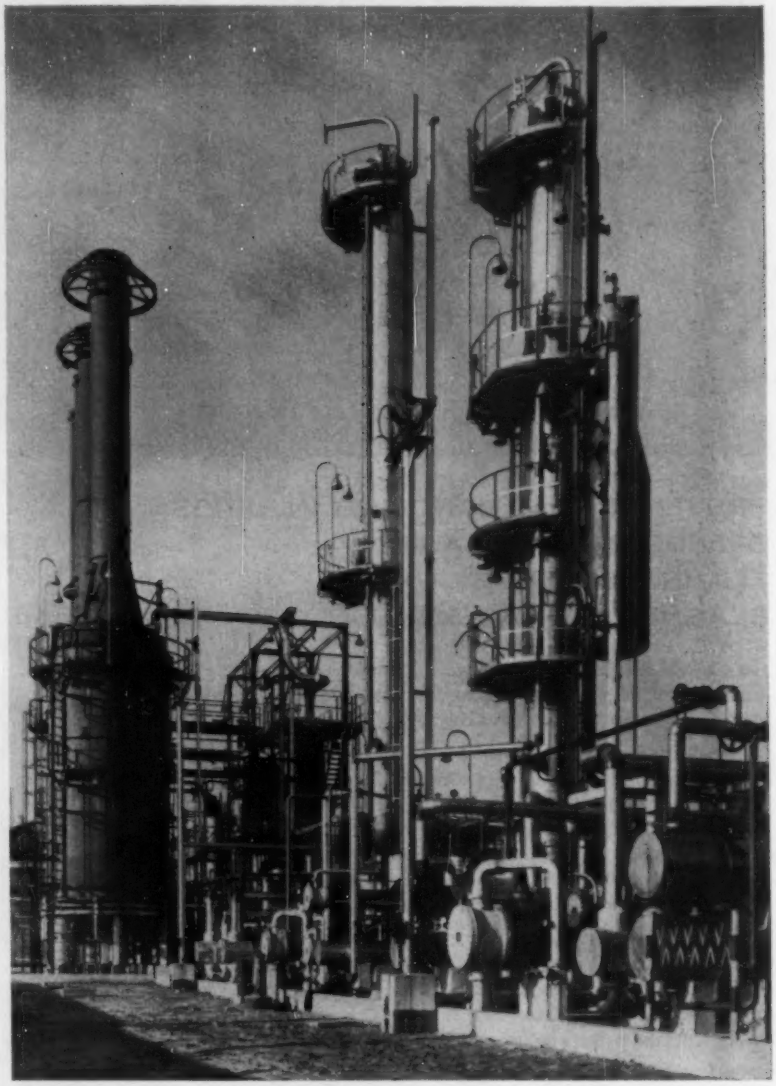
ment with new, more efficient units. Included in this program will be the primary absorber, the stripper, the secondary absorber, the debutanizer, coolers and receivers.

Another major change will boost efficiency of recovering propanes and propylenes by increasing operating pressure of the gas absorption system. This will be accomplished by reconverting the piston and cylinder arrangement on three existing compressor units to a two-stage operation with a low side and a high pressure side. At present the compressors are all low pressure units. In addition, two new compressors of 350 horsepower each will be added to the setup. These will also have a low and high pressure side.

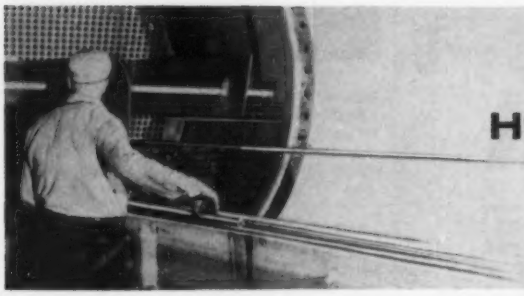


Raffinerie Belge de Petroles' Antwerp refinery will produce 88 F-1 clear octane reformate.

New Cat Reformer for Belgium Refinery

A new catalytic reforming unit with desulfurization facilities has just been placed on stream by Raffinerie Belge de Petroles, S. A., Antwerp, Belgium. The reforming unit uses the Sinclair-Baker-Kellogg RD 150 catalyst and will reform 2,500 bpd of Iraq heavy straight-run Naphtha into a 88 F-1 clear octane reformate. The desulfurizer uses cobalt molybdate catalyst and handles the total 4,600 bpd fresh naphtha feed to the unit.

The unit was designed by The M. W. Kellogg Co. for two conditions. The light fraction is stabilized in existing refinery equipment, and the heavy desulfurized straight run is reformed over a platinum catalyst and stabilized to the desired vapor pressure. The desired feed



CONDENSER AND HEAT EXCHANGER CLINIC

Edited by Arthur W. Tracy, Metallurgical Engineer
The American Brass Company, Waterbury, Conn.

25 Years' Experience has proved the Value of Arsenic as an Inhibitor

Research by The American Brass Company, completed 25 years ago, provided evidence that about 0.04% of arsenic would inhibit dezincification of brass, and this amount of that element has been added to Admiralty metal and aluminum brass since then.

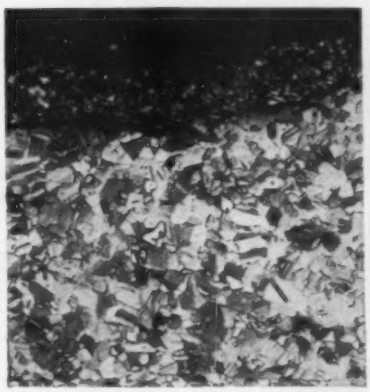
In the intervening 25 years, service experience in various fields of heat transfer has demonstrated the sound findings of the initial research, and Anaconda Arsenical Admiralty-439 and Anaconda Ambraloy-927 (Aluminum Brass) tubes have accumulated records of long service life in condensers and heat exchangers where uninhibited brasses had a comparatively short life.

Inland power stations find that Anaconda Arsenical Admiralty-439 serves well under normal water conditions, its arsenic content effectively inhibiting dezincification.

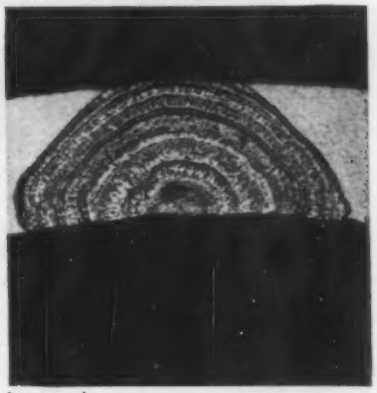
Tidewater power stations must contend with much more corrosive waters, and Anaconda Ambraloy-927, the arsenical aluminum brass, is preferred because it is not only resistant to dezincification but also to impingement or erosion pitting by either clean or polluted sea waters flowing at relatively high velocities.

Oil refineries have virtually made Anaconda Arsenical Admiralty-439 standard for refinery condensers and heat exchangers handling crudes, re-run stocks, cracked products, lubricating oils, and by-products. It is resistant to dezincification and can handle corrosive cooling waters at relatively high temperatures. Another important property is its ability to withstand attack by sulfur compounds resulting from the refining of sour crudes. Anaconda Ambraloy-927, because of its resistance to dezincification and to pitting corrosion by sea water at relatively high velocities, is sometimes preferred in oil refineries on tidewater.

TWO TYPES OF DEZINCIFICATION IN NONARSENICAL CONDENSER TUBES



(APPROX. 120X)
Layer-type dezincification on the inner wall of a nonarsenical Admiralty metal tube from an oil refinery using polluted fresh water.



(APPROX. 17X)
Plug-type dezincification on the inner wall of a nonarsenical Admiralty metal condenser tube from a power plant operating on tidewater.

Marine users generally find Anaconda Arsenical Admiralty-439 satisfactory for inland-water vessels and also for seagoing vessels where service conditions are moderate; but Anaconda Ambraloy-927 is preferred for most seagoing vessels. Both alloys are resistant to dezincification under all corrosive conditions found in these services.

Other Inhibitors—Antimony and phosphorus are also used to inhibit dezincification of Admiralty metal. The American Brass Company will furnish antimonial or phosphorized Admiralty tubes, when specified.

Technical Service—Research on corrosion problems is continuous in The American Brass Company laboratories. One important aspect of this research is the study of the growing and ever-changing problems of corrosion in condenser and heat-exchange equipment used in power stations, turbine-driven vessels, petroleum refineries and the varied processing industries. The result of this continuing research is a balanced selection of heat-exchanger tube alloys to satisfy varying requirements in current fields of heat exchange.

Our Technical Department will be glad to consider any corrosion or mechanical problem you may have with heat-exchange equipment—to assist you in selecting the one best alloy for the conditions you face. Write The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

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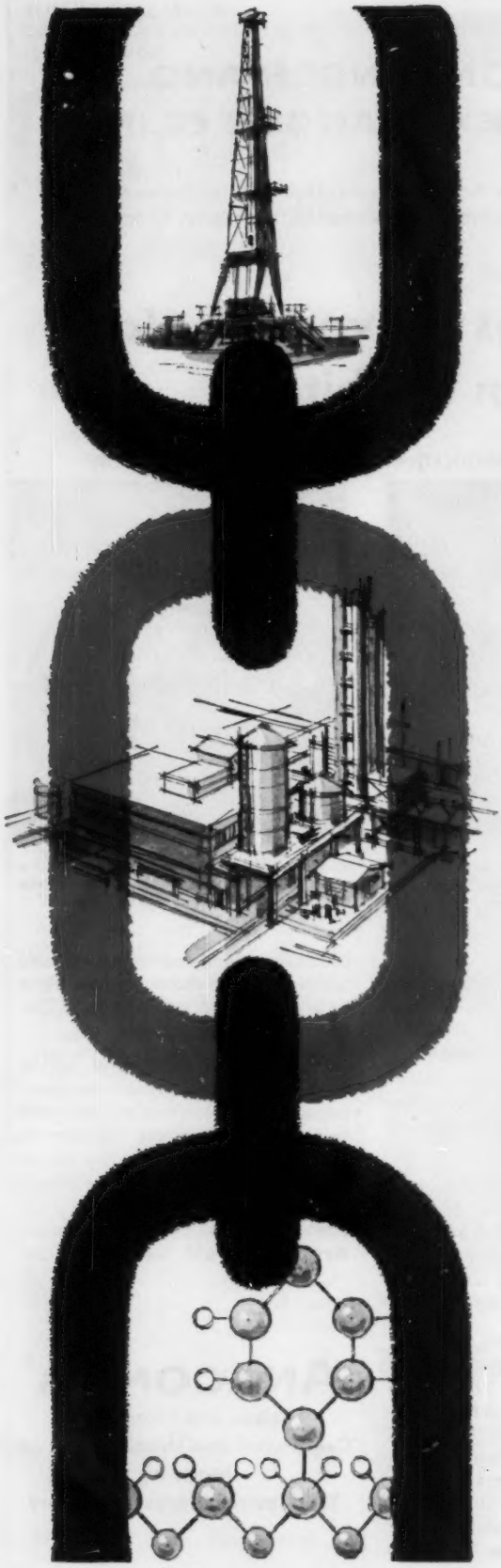

Blaw-Knox supplies vital link in Cosden's crude-to-plastic chain

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Who's Building...

rate of full range straight run to the hydrodesulfurization section is 4,661 bpd.

Simple in-place regeneration of catalyst is occasionally required. Bottled nitrogen will be used as a coolant instead of steam for regeneration of the reforming reactors.

Mitsubishi Petrochemical Co., Inc., has reported that Scientific Design Co., Inc. will design an ethylene oxide-glycol plant to be built in Yokkaichi, Japan. The plant will approximately double Japanese ethylene oxide production, and is the second to be erected in Japan using Scientific Design's direct air oxidation process. The first Japanese ethylene oxide plant went on stream in May, 1958, and is operating at full capacity.

Scientific Design will supply the process, engineering, oversee construction, provide initial operation of the plant, and supply the catalyst required for the process.

Mitsubishi will produce ethylene oxide, ethylene glycol, and other petrochemicals from raw materials supplied by Showa Oil Co.

Jefferson Chemical Co. will complete an expansion program this year, which the company says will triple production facilities for ethylene, double the plant's capacity for ethylene glycol, increase by 50 percent the production of ethylene oxide, step up output of a number of other chemicals, and bring Jefferson into the production of several new products.

The program was announced in 1956.

Kerr-McGee Oil Industries, Inc., is on stream with four new units at its 16,500-bpd Wynnewood, Okla., refinery. Included are a 7,350-bpd naphtha prefractionator, a 5,500-bpd naphtha Unifiner, a 5,500-bpd Platformer, and a 4,000-bpd middle distillate Unifiner.

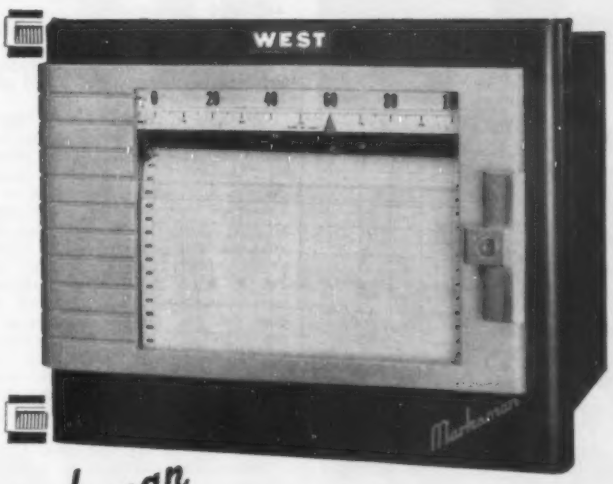
The multi-million-dollar upgrading program was started in April, 1957. The Refinery Engineering Co. of Tulsa designed, engineered and constructed the units.

Union Carbide Chemicals Co., division of Union Carbide Corp., is recasting its plans to expand production of ethylene oxide and ethanol. Company spokesmen said "one of the major reasons for this action is that recent process developments have substantially increased the output capacity of Carbide's existing plants to produce both these chemicals. Another principal factor influencing this decision is a recent re-evaluation of future market estimates, both domestic and overseas, which call for some revision of the anticipated demand for these products over the next several years."

"The Putnam, W. Va., petrochemical project that Carbide announced last year will be most directly affected by the change in plans. It was originally scheduled to be completed early in 1960. The completion date has been deferred, engineering designs are being restudied, and production and feedstock economics are being reappraised. It is too early to predict the final outcome of these studies, but best estimates at this time indicate a construction delay of two to three years."

Although details of the process developments were not revealed, the company reported that they embraced significant modifications in reaction conditions and engineering innovations. As a result, the firm's

how many?



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ethylene oxide capacity has already been raised 60 million pounds per year. These processes in full-scale operation in Carbide's domestic plants and will be utilized in the ethylene oxide units now being built in Puerto Rico and England by Carbide affiliated companies.

Throughput capacity of Carbide's Texas City ethanol plant has also been increased recently. Total ethanol capacity at this location has been upped by 20 million gallons per year.

"Although the process improvements were a significant factor in the decision to defer expansion of oxide and alcohol facilities," said Carbide, "current business conditions have slowed consumer demand. Forecasts, based on its continuing market studies, indicate a probable lag of about a year in resumption of the characteristic growth rate curve. Moreover, when the Puerto Rico and British ethylene oxide units come on stream this fall, their output will go mainly to foreign markets which hitherto have been supplied by U. S. operations. This will release substantial quantities of ethylene oxide for sale in the domestic market, lessening the need to immediately enlarge production facilities in the U. S."

Carbide expects to invest $150 million in expansion this year as previously announced.

The General Carbon and Chemical Co. has increased its conversion of raw petroleum into pure carbon for electrodes by 720 tons a day—according to Fruin-Colnon Contracting Co. The Fruin-Colnon designed and constructed calcining plant at Robinson, Ill., is producing just 12 months after preliminary engineering started.

One of the features of the plant is a combustion system that is to be automatically controlled to maintain a predetermined hot zone temperature through the use of an electronic eye that senses slight temperature changes and provides the motivation to correct gas and air flow to the burner to maintain the proper calcining conditions.

To maintain high quality of product coke, Fruin-Colnon engineers provided control of draft, raw material feed, calciner speed of rotation and rate of flow of combustion air and gas. The instrumentation allows a continuous record of temperatures, and gas flow. A qualitative analysis laboratory provides the product information for coordination with the calcining information to obtain specified results.

The coke will be processed through two 10-foot-diameter, 180-foot-long refractory lined rotary calciners. The process also includes two 8-foot-diameter, 50-foot-long rotary coolers, two 123-foot-high raw material elevators, two 100-foot-high product elevators, two 140-foot-high stacks, special dust chambers and other accessory equipment.

British Petroleum Co., Ltd., and American Petrofina, Inc. have placed a major new unit on stream at the 80,000-bpd Antwerp refinery, Belgium, jointly owned by the two companies. It is a 10,000-bpd catalytic reformer, for producing a high grade motor spirit component.

Similar units are nearing completion at three other refineries in the British Petroleum group at Dunkirk, France; Kent, England; and Kwinana, Western Australia.

Industrias Plasticas Argentinas Koppers, S.A., a partially-owned subsidiary of Koppers Co., Inc., has signed a contract with Yacimento Petrolifero Fiscales (YPF), state-owned oil company of Argentina, which may result in the construction of ethylene and polyethylene plants at La Plata, a town just south of Buenos Aires.

Koppers reported that the carrying out of the contract is contingent on several factors, including licensing and other approvals by the Argentine government and the raising of capital, a large part of which is expected to be furnished from within Argentina.

The plants would utilize gas from the YPF refineries nearby for the making of ethylene, which would in turn be made into polyethylene. Koppers would furnish the engineering and operational management.

The present plans also envision expansion to other related fields at a later date.

Esso Petroleum Co., Ltd., has obtained the British governments' permission to build a $70-million refinery at Milford Haven, Penbrokeshire, Wales. The proposal calls for a 350-acre land allotment, and approval has been given to start construction.

Egypt is seeking a $170-million loan, including refining equipment, from Soviet Russia to improve its petroleum program. Included in the request for refining equipment is a primary distillation unit (20,000 bpd) for the government's 26,000-bpd Suez refinery; a 20,000-bpd vacuum distillation unit, also for Suez; and a crude stabilizer, thermal cracking unit, fluid catalytic unit, and a 1,200-bpd lube plant.

The Atlantic Refining Co. has completed installation of a 2,100-bpd sulfuric acid alkylation unit at its 61,000-bpd Atreco Refinery, Port Arthur. Feed stock for the new unit will be furnished from a catalytic cracking unit and two Catformers, one of which was completed last fall.

Sun Oil Co. and Olin Mathieson Chemical Corp. have exchanged letters of intent to form a joint company to build and operate a 73,000-ton-a-year urea plant.

The proposed urea plant will be built at Marcus Hook, Pa., where Sun Oil has a large refinery, including a 300-ton-a-day ammonia plant.

Details regarding the organization and operation of the new company and construction of the plant will be announced when they are finalized, according to Sun.

Royal Dutch Shell has reportedly reached an agreement with the South African government by which the former will build a 75,000-bpd refinery at Durban. Crude from the Persian Gulf area will be run. Products will be intended both for the South African market and a surplus for export.

Shell Oil Co. has installed a new 16,000-bpd Platformer-Desulfurizer Unit at its Wilmington-Dominguez refinery. The new unit incorporates the latest enginering designs and will be devoted exclusively to the production of high octane gasoline components.

In the first section of the new unit, nitrogen and sulfur compounds are removed from the feed stock. These are separated from the feed stream by contact with hydrogen and a cobalt-molybdenum catalyst under high temperatures and pressures in a vapor phase hydrodesulfurizer unit. The naphthas are then passed through

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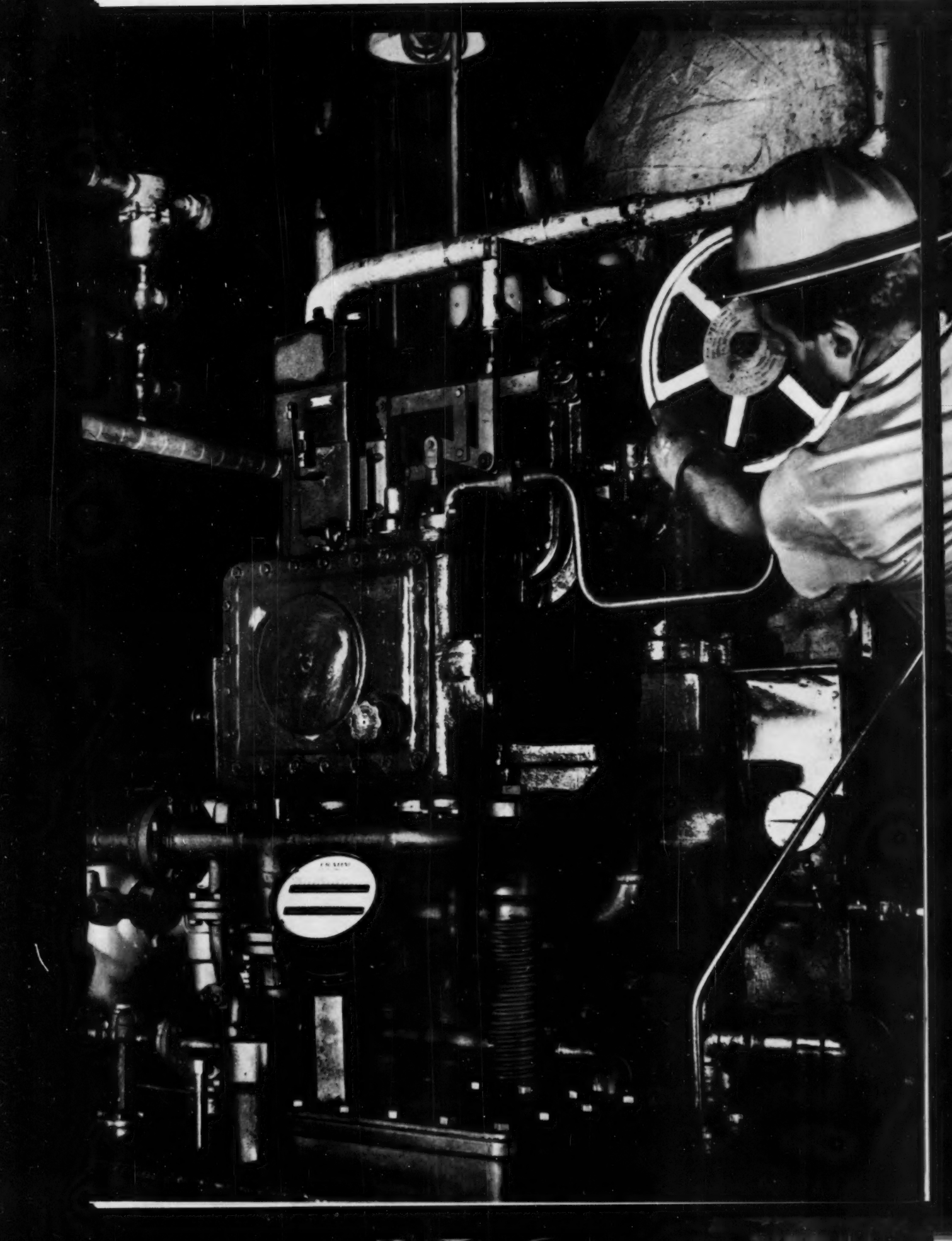
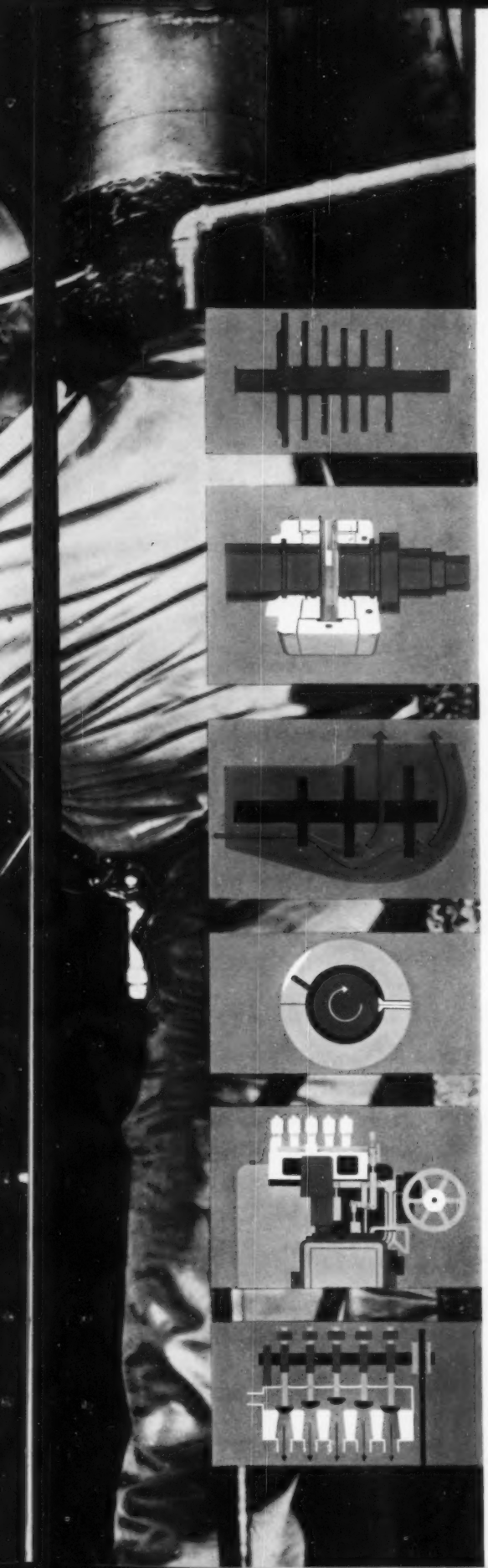




Worthington High-Speed Turbines cost more to build, are used more, are worth more

(these 6 reliability facts are some of the reasons why)

Reliability Fact #1

SOLID ROTORS keep wheel stresses well within safety margins. Where needed, wheels forged integral with the shaft are used to meet the demands of modern high speeds. Solid rotor construction, a sure method of holding wheels on the shaft, provides a more rugged conservative design. Solid rotor also decreases length of turbine, thus simplifying critical speed problems and adding to efficiency.

Reliability Fact #2

KINGSBURY-TYPE THRUST BEARINGS withstand heavy thrust loads with small friction loss and low rate of wear. Bearings have babbitted surfaced multi-segment shoes that pivot on hardened buttons. This pivoting action forms a wedge-shaped oil film between the rotating thrust collar and the shoe bearing surface. This has a cushioning effect in case of unusual shock loads in either direction. The thrust load is automatically distributed equally to the several shoes thereby maintaining internal alignment as well as holding the rotor in its axial position.

Reliability Fact #3

DOUBLE-FLOW exhaust construction on Worthington turbines reduces operating stress and increases efficiency in the handling of large volumes of steam at high speeds. Steam is divided ahead of the last stage and directed through separate rows of revolving blades before leaving via a common exhaust. Double-flow exhaust construction allows reduction in last-stage wheel size and blade length, which reduces wheel and blade stress and makes possible a simplified blade design. This permits improved nozzling with consequent efficiency increase.

Reliability Fact #4

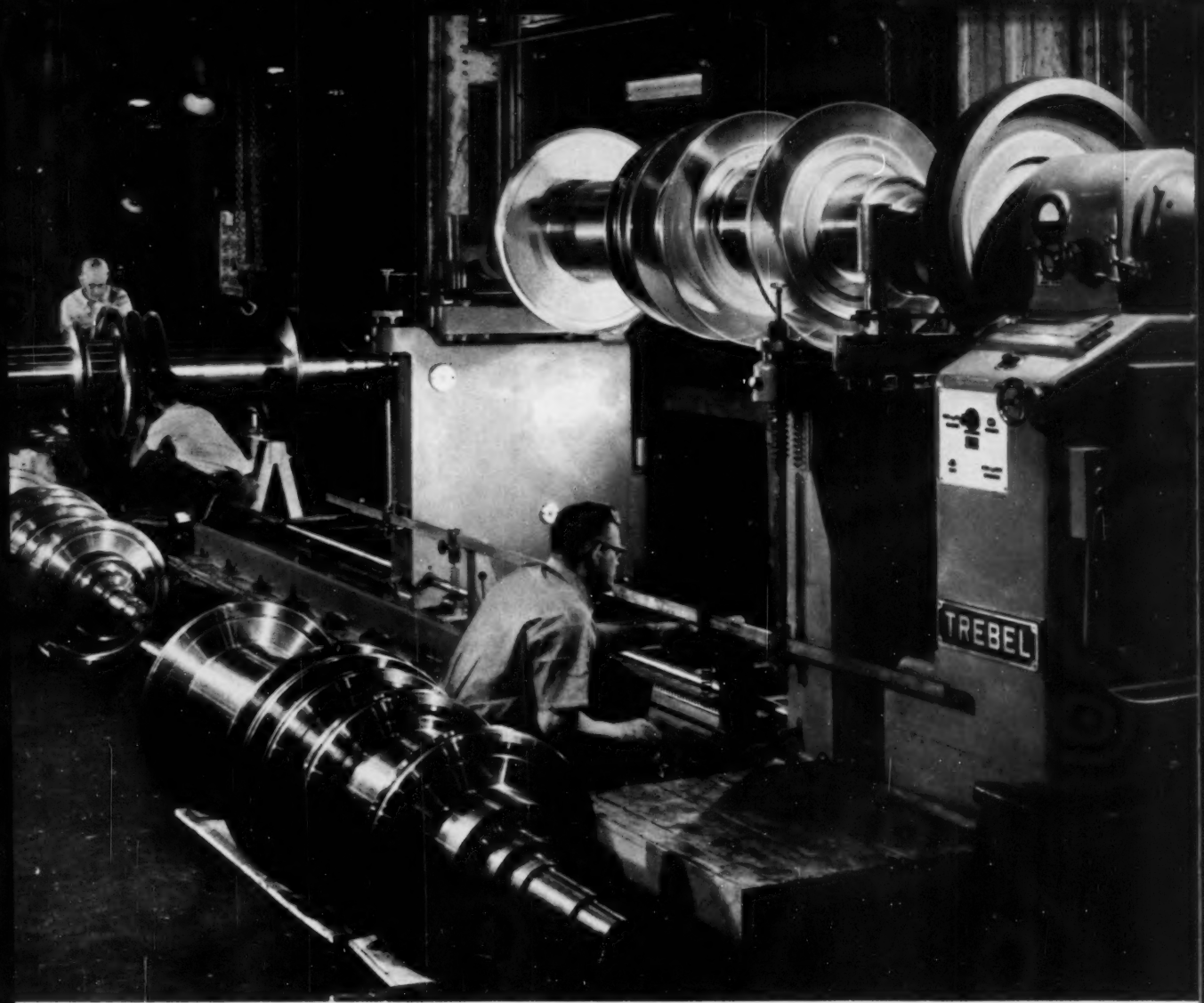
ANTI-OIL-WHIP BEARINGS are standard on Worthington high-speed turbines. A dam in the upper half of the bearing builds up a pressure pad of oil during operation. The pressure creates a downward force on the journal holding it firm in the bearing, thus keeping vibration to a minimum. Anti-oil-whip design increases life, cuts maintenance expense on bearings.

Reliability Fact #5

SENSITIVE SPEED GOVERNING SYSTEM with integral air motor combines extremely close regulation with a broad range of speed adjustment. Governor takes air impulses from an outside controller to vary speed of turbine in accordance with controller's impulse. Sensitive governor is capable of maintaining the output from the compressor substantially constant. Regardless of changes in load or steam conditions, the turbine is always under control of the speed governor, governing at any speed for which the air motor is set.

Reliability Fact #6

MULTI-VALVE AUTOMATIC NOZZLE CONTROL assures most economical operation of the turbine at all loads. Each valve automatically controls the admission of steam to a separate group of nozzles, and is operated by an independent cam mounted on a camshaft. The cams are shaped to give any desired rate of opening. The entire mechanism is mechanical, positive, and far superior to other lower-cost designs.



Balancing rotor for a 6,000 hp Worthington high-speed turbine.

THE MEANING OF LEADERSHIP

Long, trouble-free life of Worthington high-speed turbines stems from two primary sources. One: the multiple achievements of Worthington engineers. Two: the wide variety of tests to which machines are subjected before shipment to customer. Worthington, for example, is the only manufacturer that load-tests all multi-stage turbines. In this process, the turbine is coupled to a water brake so that its precise behavior under actual performance conditions can be predicted. Only when the turbine has passed this — and many other exacting tests — is it approved for shipment. This infinite attention to detail, this painstaking insistence upon perfection, explains why Worthington is today the nation's undisputed leader in high-speed turbine installations. 48-2

WORTHINGTON

WORTHINGTON CORPORATION, HARRISON, NEW JERSEY

Who's Building. . .

four reactors containing the newest type platinum catalyst, raising the octane number of the gasoline by dehydrogenation, isomerization, dehydrocyclization and hydrocracking.

The new unit has internally insulated platforming reactors, a modern control room with graphic instrument panel, and separate pneumatic systems which allow operators to shut down by remote control either section of the plant.

The unit was constructed for Shell by Kaiser Engineers, a division of the Henry J. Kaiser Co. of Oakland, and took more than a year to complete.

Panama Refining and Petrochemical, Panama, Inc., plan to build a $40 million refinery at the Atlantic coast port of Portobelo. It will have a 60,000-bpd capacity.

Foster Wheeler Corp. and the Frederick Snare Corp. will handle engineering and construction of the new facilities, and Boni, Watkins, Jason & Co., management consultants, will be in charge of the over-all project.

The plant site involves approximately 1,000 acres. Petroleum processing units, marine terminals, extensive bunkering facilities, tanks for crude and finished products and a petrochemical plant will be erected.

Construction work is expected to take approximately 18 months and employ between 1,000 and 1,500 persons.

Daikyo Oil Co., Ltd., of Tokyo, has placed a 3,000-bpd Houdriformer on stream at its Yokkaichi refinery.

The new Houdriformer is producing high-octane gasoline from naphthas derived from the Arabian and other Middle East crudes processed by the Yokkaichi refinery. It consists of three catalytic reactors and an integrated pre-heat catalytic guard-case reactor for feed stock purification. An integral part of the unit is the apparatus for in-place regeneration of the platinum catalyst.

Daikyo's new catalytic reforming unit is the first in the Far East and joins the 4,200-bpd Houdriflow catalytic cracker, also first in the Orient, at the Yokkaichi plant. The cracker has been on stream since June, 1955.

Houdry Process Corp. furnished the process design for the new unit. Engineering was handled by both Houndry and the Refinery Engineering Co. of Tulsa, while Daikyo handled construction.

The Copolymer Corp. is planning a $3 million expansion of its Baton Rouge chemical plant. Facilities will be provided for the production of a new type dry rubber product containing carbon black.

A company spokesman said use of the new product will permit manufacturers of finished rubber goods to increase plant output, reduce warehousing, and maintain cleaner plant facilities. The $3 million program is in addition to a $6.5 million program already underway.

Jordanian Refinery Co. officials have referred tenders for a refinery construction contract to the company's Dutch consultants. Tenders were received from West German, American, Italian and British companies.

The refinery would be completed within 26 months and have a capacity of 330,000 tons of crude annually.

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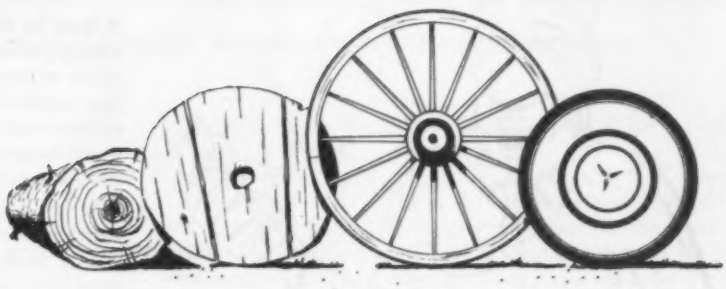


Part 1: How to Invent

If you have never invented, it doesn't mean you lack the talent—no doubt you just need proper training. These articles will teach you the mental techniques of learning to invent, and how to apply them to your daily thinking

Forrest E. Gilmore
Independence, Kansas

IN MY RATHER extensive contacts with engineers, especially young ones, I find that most of them would welcome some magical way by which they might become inventors. When urged to submit patent ideas, they do not know how to obtain them or even how to start learning to create them.

Most of them have heard of the highly publicized technique called "brainstorming" and assume, therefore, it is the method to use. It is true that for persons prepared for invention this technique may be useful at times, but it is only one of the tools available for ideation and is not particularly applicable to the type of invention in which engineers should be proficient.

Because of the apparent need, these articles will be presented to help you realize that learning to invent is important to you. They will supply the "how" which coupled with diligent and faithful practice will ultimately develop your inventive potentialities. They will also acquaint employers and supervisors with the inventive process and its importance in promoting the welfare of business. This insight into inventiveness will help those of you who are supervisors obtain greater productiveness from the engineers responsible to you.

No Genius Needed. To invent, you do not need to be a genius—for invention is usually planned thinking and action to obtain some fairly definite expected result. Well known methods of solving problems of human needs are nearly always used in making the invention. These methods can be learned and skill in applying them can be acquired.

It is not easy to become a successful inventor, and there is no magical way of becoming one. However, as an engineer you should understand the fundamentals of the inventive process and know some of the techniques used by successful inventors. Learning how to invent is an interesting and profitable occupation, and the strenuous effort required for success is well worthwhile.

Many engineers, without adequate preparation, try a few times to invent but when their patent ideas are found unacceptable or anticipated, decide they have no inventive talent and quit. They are like some inexperienced salesmen who quit after a few calls, convinced they cannot sell. They either don't know or appreciate that investigations have shown the average first sale is made on the eighth call. Like the good salesman, the main characteristic of the successful inventor is his willingness to keep on trying.

Creative Thought Before Man. The mystery of creative thought has been a challenge to all brilliant men throughout time, and many of our greatest inventions

There is no magical way to become an inventor . . .

were made before the dawn of history. Invention appears to have existed even among the animals with such things as bird nests, beaver dams, bee hives, ant hills, etc.; these inventions with time crystallized into instincts.

According to the *Encyclopedia Britannica* the world's seven most important inventions have been:

- The function of seeds and plants
- The control of fire
- Pottery
- Writing
- Standards of measurement
- The germ theory of Pasteur and tinned foods.

In all but one of these the inventor or inventors were unknown, and three occurred before the dawn of history.

As invention is old, so is the inventive process; even Aristotle and Plato wrote about it. Philosophers, psychologists and scientists have given it so much consideration that a great deal of information about successful techniques is available.

Knowledge of the techniques of invention increases the efficiency of trained minds, so its study is practical for all engineers and others interested in improving their creative thought. You probably know very little of these techniques, and even less of where to look for them. Perhaps you don't even realize that much has been observed and recorded about them.

Actually, the fundamentals of learning to invent can be learned quite readily, but the ability to apply these fundamentals efficiently usually cannot be obtained quickly. A high degree of concentration is required as well as a procedure which is contrary to your usual habits of thinking.

At this point let me pause to remind you that simply because you have never invented anything does not mean that you have no talent for it. No doubt you do have the talent, but merely lack the proper training. And even if this training never leads to a patentable invention, learning how to invent will most assuredly benefit you in many other ways.

A Key to the Future. In world affairs, inventions cause change, development and evolution. Therefore, a broader effort to encourage inventive thought is needed for solving problems for the benefit of humanity. Knowledge of how to invent may well be the key to many new products and inventions which will surely transform our environment, and supply many of our needs.

It is possible that any problem found insoluble by known means is actually insoluble—but more likely the known means are inadequate or wrong, and therefore, some new and original approach is necessary. Our progress and perhaps our very existence depend on such new and original approaches to solutions which stem from the creative or inventive process. Our actions should be governed by this understanding.

As musical composition is the highest expression of the musician's skill, so is invention the prime product of engineering skill. As far as I have been able to determine, all renouned engineers have been great inventors and some invention has been the basis of nearly every great achievement and fortune. As an engineer, you are an inventor. Most philosophers observe that intelligence is nothing more than perpetual and constant invention; you cannot avoid it as it is a part of your thinking and living. In reverse, the greater your thinking and living, the greater your inventing is apt to be.

Beware This Pitfall. Most inventive-minded engineers learn to invent rather haphazardly by trial and error, by contact and observation of others and by introspection. This tends to produce what are termed "crack-pots." Creative thinkers must always beware of the very real danger of gaining a reputation as visionary or radical and therefore untrustworthy. Those who do a thing differently, loving novelty for its own sake, must frequently be in the wrong and are not trusted by their superiors. One of the basic requirements for men in authority has long been expressed thus: "He has his feet on the ground." Although undoubtedly many a serious mistake has been made by putting such unimaginative men over those of superior creative ability, it is still being widely practiced.

This fact should not discourage you from learning how to invent, but should warn you of possible consequences which you can avoid by using good judgment and being cautious of the impressions you make on those around you. Usually engineers who appear to be untrustworthy because of their desire to try out new things become more cautious when authority is given to them. All supervisors should keep this in mind when considering giving authority to such engineers.

R & D Often Inadequate. One point which has an important bearing on the success of inventive persons within large corporations deals with the reluctance of planning personnel to take any chances by using promising new processes or equipment which appear to be superior to what is usual. Management generally tries to overcome

"Extensive research has indicated that, with a minimum IQ of about 120, creativity depends more on personality than intelligence . . . with the proper training the creativity of this country's engineers could be increased at least eight times."

this through the operation of a research and development department. However, such a department is usually so far removed from most of the practical operations of the company and operating personnel, and so interested primarily in its own problems that it does not have sufficient incentive to plug for and test new ideas advanced by operating personnel.

If a chief engineer of an operating department recommends anything distinctly new and it does not work out satisfactorily or someone of a reactionary mind *thinks* it does not, it will likely become known as, "the chief engineer's folly." If it does work out advantageously, no one gives him any special recognition. So, to be safe, good judgment tells him to always use a process which has been completely proved, and have it designed and installed by a highly responsible firm. Frequently the costs are higher and the results poorer than would have been obtained had he taken a reasonable business risk. This problem is one for top management of each company to solve and calls for some creative thinking or invention.

"In the Beginning." A consciousness is widely growing that all the infinite laws of science are God's laws. One might say that invention is the art of using these laws to create out of matter new things or improvements in old things.

All people and things are tremendously affected by invention; civilization and history are made by it. This becomes quite clear when we think of the impact made on society by such things as the steam engine, electricity, the steamboat, the cotton gin, the internal combustion engine, the telephone, radio, automobile, airplane and now the nuclear reactor. Also, works of art such as pictures, sculpture and music are inventions and add their great effect on society along with the more tangible ones.

Today, probably the most salient agent affecting civilization is the invention of a means by which we can use nuclear energy. It undoubtedly heralds the truly scientific age with all its boundless possibilities and calls for a greatly accelerated rate of invention—particularly of the deliberate type. The approaching conquest of space is just one aspect of the scientific age through whose prologue many of us have lived.

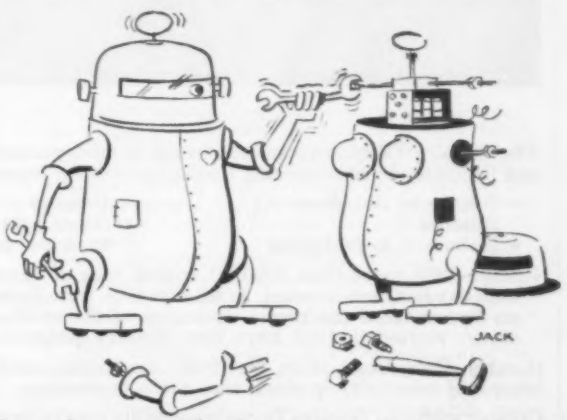
Creativity Depends On Personality. Perhaps the outstanding characteristic of this maturing scientific age will be education for creative thinking instead of for conformity to established thinking as in the past. Extensive research has indicated that, with a minimum IQ of about 120, creativity depends more on personality than on intelligence. It is well established that personality is more subject to human control and development than intelligence. Estimations are that with the proper training, the creativity of this country's engineers and scientists could be increased at least eight times. This is probably essential for our survival as the leading industrial country of the world, perhaps even for survival of our free way of life which is being challenged.

One way for us to strengthen our country and meet this challenge is by helping alert thinking people realize the part invention can play and how they can learn and teach others to invent. Each of us should watch his every reaction to new and original ideas, especially those of youth that criticisms do not dry up the desire for creative thoughts and actions.

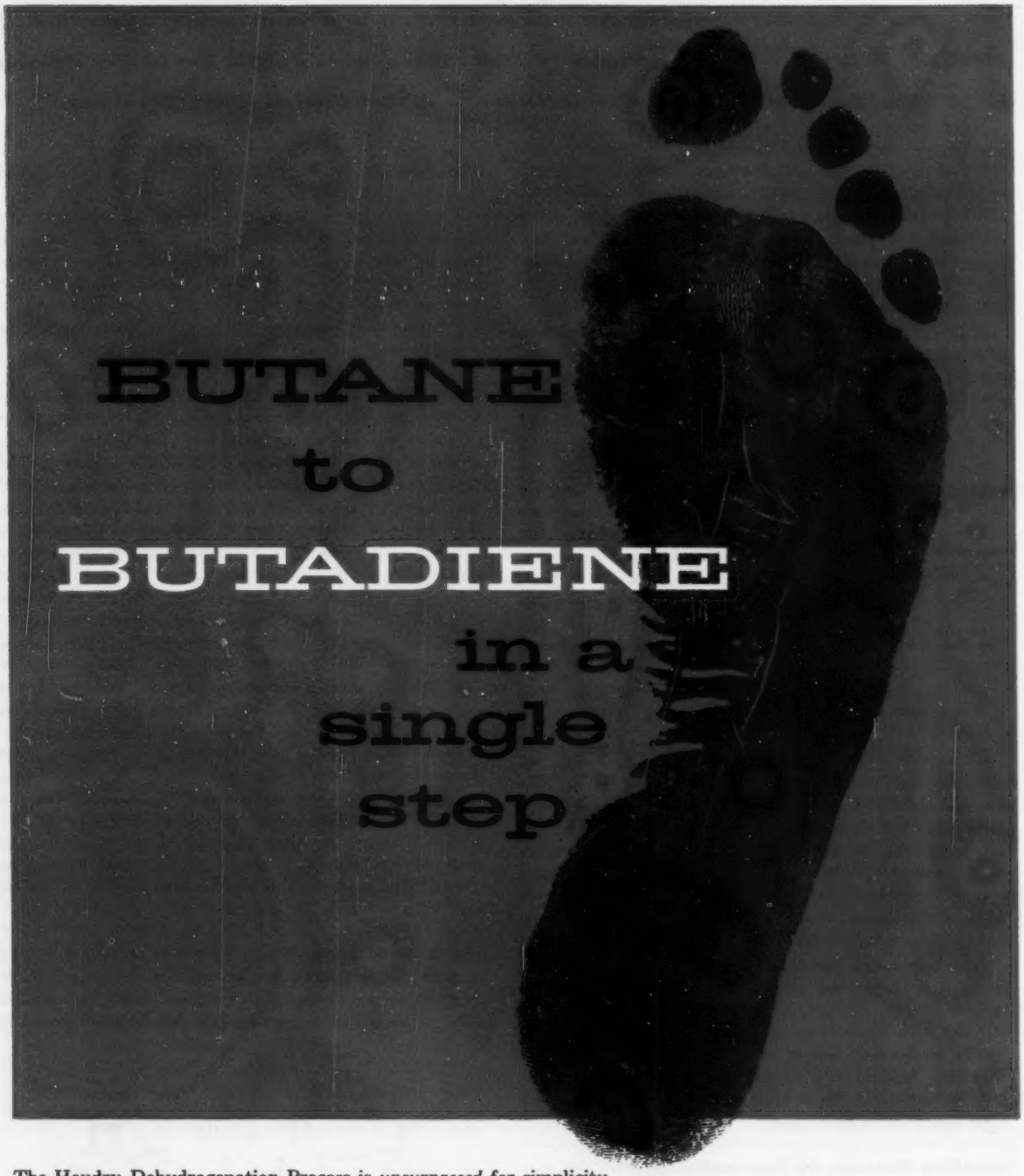
Look to the Masters. Almost all great men who have written anything of importance have done so as a result of creative thinking or invention; the two terms being almost identical in meaning. Many have written of their methods and the importance of creative thinking in their successes. A study of such successful creative thinkers and their ideas of what made them successful seems to be the most authentic source for information about how to create successfully. Therefore, I have gone to the records of such creative persons for ideas of how they became creative and studied how they could be applied to the more common run of people such as myself. These famous people included Edison, Einstein, Plato, Aristotle, Poincare', Socrates', Descartes, Mozart, William James, Emerson, Kettering and many others whom the world owes a tremendous debt for their contributions.

As an illustration of the magnitude of this debt, upon the awarding of the Congressional Gold Medal to Edison in 1928, it was then estimated that his inventions had contributed a value to humanity of $15,599,000,000. It is certain that we owe practically all of our unprecedented material advantages, general freedom from contagious diseases and leisure time to the contributions of the inventors who preceded us.

The Role of Man. It has been said that God created man to be his partner in the work of creation. It is not unreasonable to conclude, therefore, that God created man to be a creator; giving him intelligence instead of



Inventions to make instruments to make instruments, etc. . . .



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Houdry Dehydrogenation Catalysts are unsurpassed, too, for stability and selectivity in single-step olefin production.

Consult with us—Houdry Dehydrogenation may be profitable for you.

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*Houdry means Progress . . . through Catalysis

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Even Aristotle and Plato wrote about inventing . . .

wings like a bird, fleet legs like a deer, eyes like an eagle or a nose like a hunting dog, so that he could invent and manufacture his own instruments, including instruments for the manufacture of increasingly complex instruments. All of our civilization rests on this divine gift of intelligence whose essence is invention and by which matter is mastered and utilized.

Invention to make instruments to make instruments, etc., ultimately results in automation—one of the most important and controversial of modern manufacturing techniques. Its application is well stated by a parody on a Dean Swift poem by William H. Miernyk of Northeastern University.

> "Machines the engineers now say,
> Will themselves be making machines some day.
> These machines will have other machines to
> guide them,
> And so ad infinitum."

Another interesting comment on automation and invention of the future is in the NAM pamphlet "Calling all Jobs": "Automation is a magical key to creation . . . for the expanding dynamic economy of America, the sky is the limit. Guided by electronics, powered by atomic energy, geared to smooth, effortless workings of automation, the magic carpet of our free economy heads for distant and undreamed of horizons. Just going along for the ride will be the greatest thrill on earth."

It is interesting to imagine what the history of the future may be like. Possibly part of it may be somewhat like this: The principal cause of the American and French revolutions was the Industrial Revolution. This Industrial Revolution was a movement broadly asserting the right of an individual to live, to hold property and to have a voice in his own political government. However, the Industrial Revolution was almost entirely due to the *invention* of the *Steam Engine.*

The Value Herein. Lately, many worthy and useful techniques have been offered for improving our chances for success in our various endeavors, telling us how to make friends and influence people, how to remember, how to have a vibrant personality and others. To these I now offer what I have learned about how to invent. Much of this has come from others. I find that many of my conclusions from my own experiences, observation and introspection almost exactly parallel those of others who have written about them. However, much of what was previously written is in a language difficult for ordinary engineeers such as myself to understand. I hope these articles will serve to render much of this knowledge more acceptable to you.

In Part 2 which will appear next month, the author will discuss such highly interesting and informative subjects as:

1. **The most common mental block to invention.**
2. **How to exercise your imagination.**
3. **Role of the subconscious mind in inventing.**
4. **What part intuition plays.**
5. **Those sudden illuminations which clearly show the answer to a difficult problem.**

About the Author

Forrest E. Gilmore was an engineering consultant and patent administrator at Phillips Petroleum Co.'s Refining department before his retirement in January, 1958. A consultant on process engineering, he was a trouble shooter at various refineries. He also promoted patent ideas and taught engineers how to invent while with the Liaison Refining department and Patent division.

Gilmore

Gilmore began his engineering career after receiving a B.S. degree in civil engineering from Kansas State College in 1916, and graduating from the School of Military Aeronautics at Austin, Texas, in 1918. That same year he became a consulting engineer in the natural gasoline field for Frank T. Peterson & Co. of Tulsa.

In 1921, Gilmore formed the Forrest E. Gilmore & Co. Consulting Engineers, which designed and constructed ten gasoline plants in three years. It was then merged into the Forrest E. Gilmore Co. of Calif., of which Gilmore was executive vice president and manager. This company was taken over by Forrest E. Gilmore Co. of Del., in 1926, and 13 gasoline plants were built. In 1928 he sold his interest in this company and formed Airolene Gasoline Co.

In 1932, while continuing as president of the Airolene and Philmore Gasoline companies, he became president of the Frigid Transportation Corp., a corporation owned principally by The Standard Cap & Seal Corp. There he met Harold E. Talbott, chairman of the board, and Walter P. Chrysler. In 1938 they pursuaded him to head an oil exploration company, Black River Oil Co., which Chrysler had organized. However, Chrysler died and the company was dissolved.

Gilmore then represented Talbott in connection with some small oil properties in Texas. In 1939, the very low price of natural gasoline caused operation of Airolene Gasoline Co. plant to be unprofitable and it was discontinued.

In 1941, Gilmore joined Phillips Petroleum Co. in the Gasoline department. Through the years he held posts as coordinator, administrative assistant to the vice president, assistant superintendent of operation, assistant chief processing engineer, engineering consultant, and patent administrator of the Patent department.

Which is the best way to compress gas?

That depends. The compressor that's right for small volume flow isn't right for large volume flow—and vice versa. With the widest selection of compressors in the field, Carrier has the right unit for your process. Equally important, with greater experience handling more different gases in its compressors than any other manufacturer, Carrier offers application skill unmatched in the industry. Shown below are a Carrier Centrifugal Compressor for small volume flow and an Axial Flow Compressor for large volume flow. For complete information about them, call your nearest Carrier office.
Or write Carrier Corporation, Syracuse, New York.

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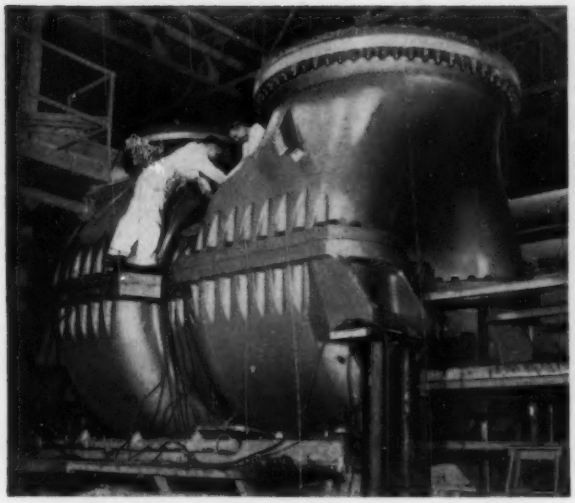

For large volume flow beginning at 75,000 cfm, Carrier Axial Flow Compressors are the answer. This unit, rated at 276,000 cfm, was made for use in a butadiene plant in the southwest. Carrier Axial Flow Compressors offer distinct advantages for large volume flow. Their high efficiency effects a significant reduction in operating costs. And their dependability is proved—the hundreds now in use have given reliable service for a total of over 60 million operating hours. Frame sizes are rated up to 600,000 cfm when operating on air.

For small volume flow starting at 1000 cfm, Carrier Centrifugal Compressors are the answer. This unit, the smallest in the Carrier centrifugal line, is installed in a refinery in Texas. Carrier has manufactured compressors that withstand pressures up to 2400 pounds, are driven with drivers of over 10,000 hp and attain extremely low temperatures. Their ability to run 24 hours a day, 7 days a week, year in and year out, is a matter of record, demonstrated in chemical, petrochemical and refinery processes in plants throughout the world.

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Do You Use WORD MAGIC?

Choice of words can make a job fail—or succeed.

Jack E. Bedford
Berkeley, Calif.

TO GET THINGS done in a refinery requires some means of communication. The vehicle to carry the message may be a notice on the bulletin board, an announcement over the public address system, a written report or a personal conversation.

Regardless of how the message is delivered, the employe communication must be completed with words. How successful we are in getting people to do the things we want will depend on our choice of words . . . word magic.

Here are some words and phrases that refinery supervisors have found most helpful in building better employe communications...word magic that gets things done.

When. Positive thoughts are expressed in positive words—and positive thoughts get things done.

Consider, for instance, these two requests made by a refinery supervisor:

"If you get time, do this. . . ."

"When you get time, do this. . . ."

Except for the change of one word these two requests are exactly the same. But, the change of one word changes it from a negative to a positive request.

"If" is a weak, wavering, vacillating word. It makes it easy for the employe to procrastinate. Things are put off rather than getting done.

"When," on the other hand, is a strong, stimulating positive word. It gets things done quickly and with a minimum of friction.

Yet, because the request is prefaced by "when," it is not a command that will arouse resentment of the employe. Instead it gives the employe a choice of *when* he will perform the task, not *if* he will do it or not.

To apply this word magic in your employe relations, you will need to do two things:

1. Think positive thoughts about getting the work done.
2. Preface your work request with "when" instead of "if."

Another way refinery supervisors use the word magic of "when" to get things done is by asking a question. The employe is given a choice in the question which starts with the word magic "when."

For instance, you might want an employe to do something as soon as possible. You would ask,

"When can you do this—today or tomorrow?"

This assumes the employe will perform the task. It has the positive approach. And, it gives the employe a feeling of importance because he can make a decision of doing the work today or tomorrow.

As this question is phrased, there is a good chance that the assigned task will be done tomorrow. But, if there is an urgency about getting it done today, you could change the order of the choice in your question. For instance,

"When can do you this—tomorrow or today?"

You put emphasis on the time you want the work done by placing it as the second choice. This is the last thing the employe hears, and chances

The five simple words shown above can make a refinery project succeed or fail.

Heliflow® Excels Any Other Heat Exchanger

This has been proven in virtually every job—and it's a "bearcat" for the real tough ones.

May we ask you just a few questions concerning your next heat exchanger job?

Do you have high operating pressures?

Are you pinched for installation space?

Do you have a severe temperature condition—thermal shock?

Do you require close temperature approach at both ends?

Is costly alloy construction required?

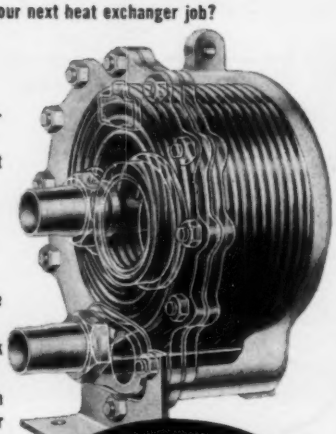
Is absolute mechanical dependability a "must"?

Is minimum liquid volume advantageous to you?

Would you prefer to condense and sub-cool in one shell?

Does shipment from stock or, in any event, quick shipment interest you?

We don't have to ask if you are concerned with low cost performance and handling more BTUs for your dollar—certainly Heliflow does all of this but, again, for the real tough jobs you will find Heliflow the optimum choice . . . indeed, real Thermal Magic.



Graham

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are good that he will give you the answer you want.

You can use other choice words in addition to when. Some of the most effective of these prefacing remarks start with the magic words—"when," "which," "what," "how." Any of these words will key your questions to give the employe a choice between two things.

Another thought to keep in mind about using this word magic in question form is to make the choice between something and something . . . not between something and nothing.

For instance, asking the employe when he can do the work leaves the answer wide open to time. But, when the choice is nailed down to the choice between today and tomorrow, the employe will answer with one of these choices.

"When" is word magic that gets things done!

For Example. One of the most important parts of a refinery supervisor's management function is training employes. On-the-job training takes on added emphasis when you employ word magic.

For example is basic word magic in training. We use it all the time. We all learn through illustrations of the right and the wrong way to do things. And, since we are so conscious of this learning method, we are alert for examples that will help us understand better.

When you preface your instructions with the words, "for example," you snap the employe being trained to attention for your illustration. He is eager to learn how it is done and listens to your example.

In using this word magic, you will want to consider a few rules. First, the example you use should be given to prove your point. You make your point and then follow it up with the word magic, "for example."

Second, you want your example to be specific. You will make it more interesting and more memorable to the employe you are training when you use specific terms.

Third, your example should be relevant to the point you are presenting. In training this is usually automatic, but it may be necessary to change a few examples to make them apply to the problem you are discussing.

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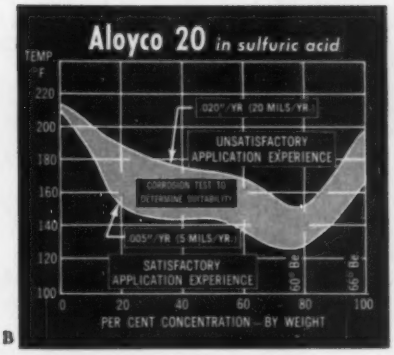

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C

D

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B. Right Alloy for your application is based on 29 years of specialized experience in the field plus continuing research in Aloyco metallurgical labs.

C. Valve Casting is made from Aloyco design in Aloyco foundry, only foundry ever built to produce pressure-tight Stainless Steel Valve castings, exclusively.

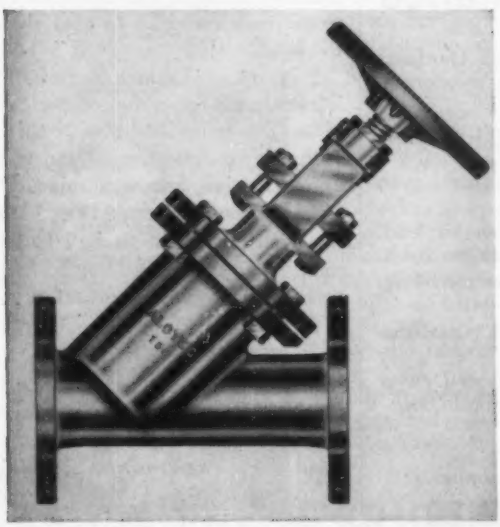
D. Special Techniques in machining stainless steel, plus most modern equipment in Aloyco plant assure you precise tolerances, trouble-free performance.

E. Aloyco Y Valve, shown here in various stages of production, is one of Aloyco's complete line of valve types, alloys, sizes, pressures — including nuclear valves.

BEHIND EVERY ALOYCO VALVE...

specialization

... to help you handle corrosives


E

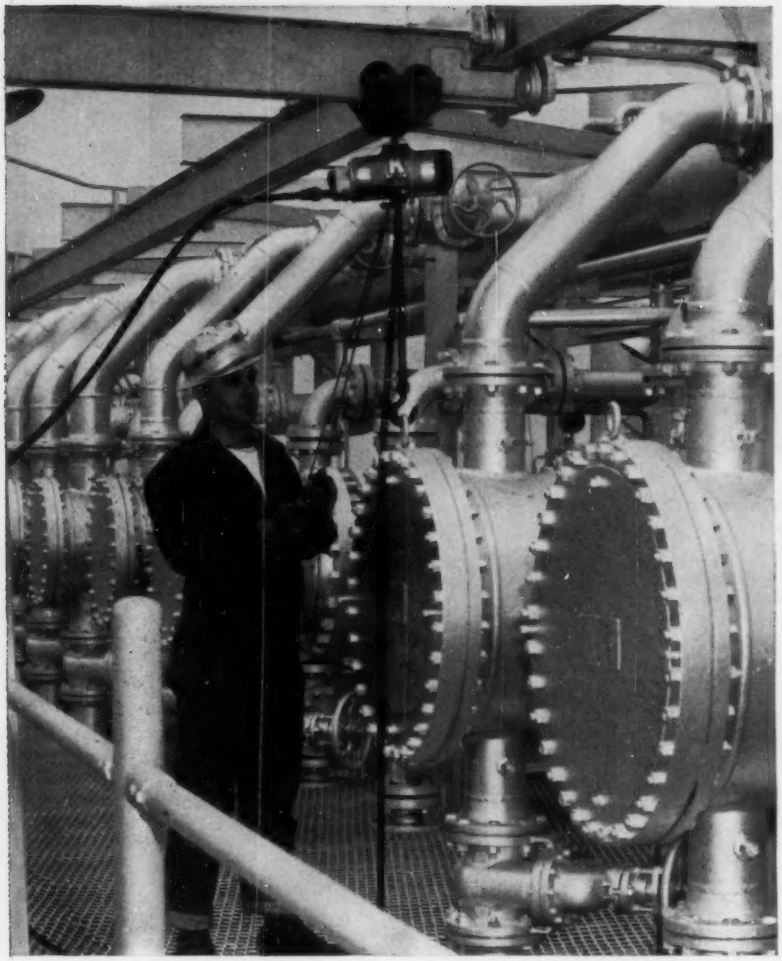
Valves often look alike—even stainless steel valves. But they won't necessarily perform alike when you get them into the line.

Here are some of the special skills and facilities that make the difference between Aloyco valves and others. Some of the "extras" you get with Aloyco valves are staying power, minimum maintenance, trouble-free operation in severe as well as mild corrosive service. Doesn't it make sense that the one company specializing in the manufacture of Stainless Steel Valves exclusively is your best source of supply?

D-2

ALLOY STEEL PRODUCTS COMPANY

1303 West Elizabeth Avenue, Linden, New Jersey



For lifting channel covers, tube bundles, or any heavy lifting job up to two tons, there's a Gardner-Denver air hoist to handle it.

Handy hoist for refinery maintenance

On day-to-day maintenance or during turnaround periods, let Gardner-Denver air hoists lighten your lifting jobs. They're fast, safe, easy to operate. Here's why:

Air motor power—can't be damaged by overload stalls. Can't spark or burn out. Motor is sealed from dirt and corrosive fumes.

Powerful brake—prevents racing, will hold load in complete control even if air line is disconnected.

Load chain—roller or link. Tested to two times maximum rated load. Adjustable safety stops shut hoist off when load is at maximum limit.

Safety hook—made of forged steel . . . ball-bearing mounted for swiveling. Will accommodate load in any position.

Controls—control bar or pendant control system provides effortless one-hand lifting or lowering.

Choose the safe, spark-free lifting power you need from the Gardner-Denver air hoist line. Seven models from 150 lb. to two tons. Write for Bulletin 86.

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

Fourth, you will find the "for example" word magic more effective if you add some variety to it. You can use these phrases to spice up your instructions—"as a case in point," "to illustrate" and "for instance."

Fifth, you will want to be alert to examples that you can use to point up your instructions. By collecting examples of both the right and the wrong way of doing something, you will make your instructions more interesting.

Yes, but. Communications between supervisors and employes can bog down when an argument develops. Everyone has opinions on different subjects, and some employes are prone to express their views in no uncertain terms. When there is a conflict of viewpoints an argument is the natural result.

Good employe relations has a basic principle that is well known to all refinery supervisors—Don't argue! Yet, there are times when it is important to change an employe's ideas and opinions to make the work move smoothly and to get things done.

The "yes, but" word magic can do this for you. When an employe raises some objection to doing something or accepting some rule, you employ the "yes, but" word magic. Here is a three-step plan to follow in using this word magic:

1. You agree with the employe. You say "yes" to his thoughts and ideas. This softens the blow of your counter argument and makes the employe more receptive to your side of the issue.

2. You cushion the argument. This is merely an expansion of the "yes" idea. You agree and you continue with this agreement to get out of the argumentative frame of mind. For example, you might say: "Yes, I know how you feel about that. I had the same idea for a long time. In fact, I was sure it wouldn't work. But . . ."

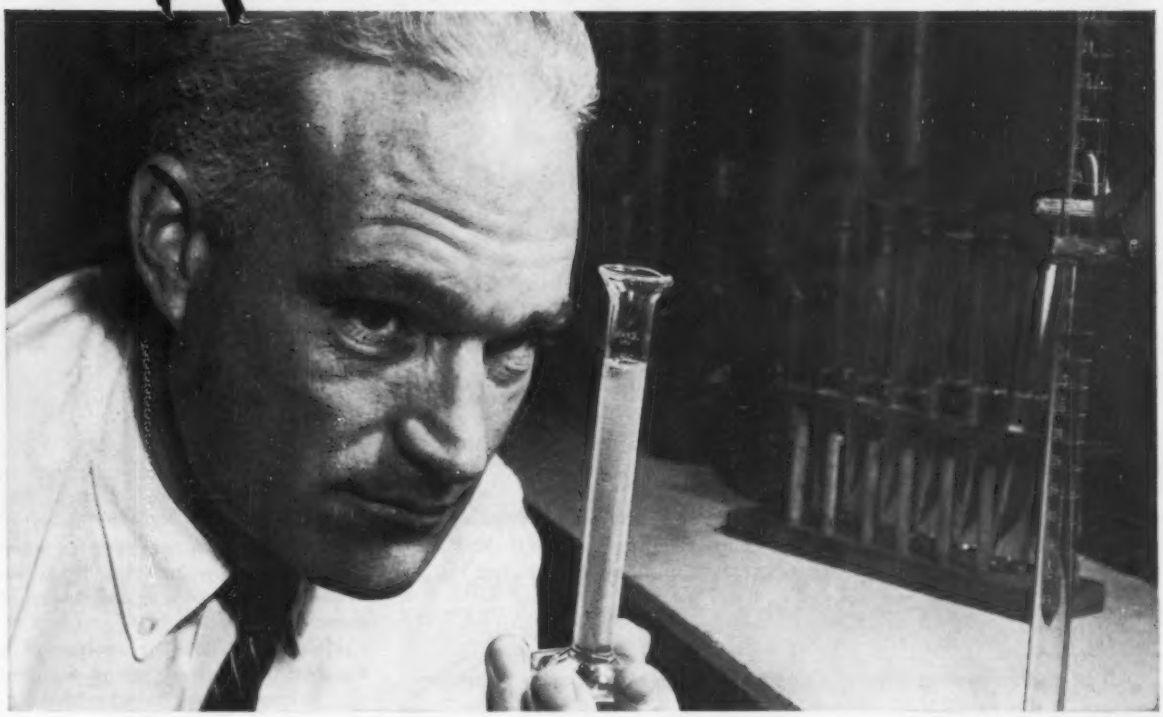
3. You present the other side of the argument with a "but" preface. You will find that this "yes, but" word magic will keep you from starting an argument and will help open the mind of the employes you are talking to.

Why not try this word magic in the next employes relations problem that develops? # #

For more data on advertised products, use Readers' Service Cards, last page.

BRIDGEPORT "T" MEN* IN ACTION

**Technical Service Men*



The Case of the Acid Assailant

Where's the Culprit? Field spot tests of water samples give revealing clues as to cause of corrosion.

Case Solved. Initial recommendations go out to customers immediately and are followed by a detailed written report.

It was an ordinary afternoon in the Corrosion Lab when a sample of raw cooling water and a corroded condenser tube arrived from a midwest chemical company. Accompanying the evidence was a letter of explanation and a completed Technical Service corrosion questionnaire. The customer wanted help. Bridgeport "T" men swung into action.

The water sample was analyzed. It checked out against the original sample taken when Bridgeport tubes were first installed. Still no conclusive evidence of corrosive media was found in the water. Yet, examination of the tubes revealed them to be corroded both by acid and an abrasive.

The Bridgeport "T" Man visited the plant site and retraced the case step by step.

The first break came when a spot check was made of water taken directly from the cooling tower. A significant acid content was noted. Further on-the-spot examination showed that gas and fly ash from the plant smokestack were carried by prevailing winds over the cooling tower and deposited in large amounts in the tower. Closer examination of the cooling tower uncovered acid-forming sludge and abrasive fly ash in suspension.

The Bridgeport "T" Man, in an extensive report of his findings, recommended corrective measures. Company adopted recommendations. Tubes saved. Case closed.

This is a typical case from the files of Bridgeport Technical Service, a group set up to help Bridgeport customers get maximum life and service from their power and process equipment.

For the best service and advice on condenser or heat exchanger tubes call your nearest Bridgeport Sales Office today.

BRIDGEPORT CONDENSER TUBES

Bridgeport

Bridgeport Brass Company, Bridgeport 2, Connecticut

Sales Offices in Principal Cities • In Canada: Noranda Copper and Brass Limited, Montreal

For more data on advertised products, use Readers' Service Cards, last page.

Accidents—What Do They Really Cost?

Too often only the immediate outlay of dollars is computed. Here are a dozen "hidden" costs which also eat away at your profits.

One of the most misleading situations in modern refinery operation today is created where management fails to determine the true costs of accidents. Too often, only the immediate outgo of dollars and cents is used as a yardstick. Actual cost analysis has shown this to be far from true.

Arriving at the true costs of accidents requires detailed and close analysis of many factors—not just the two or three which are most obvious. Even the smallest accident has hidden costs which can eat into profits. Therein, too often, lies the source of hazy or unknown operating expenses and too narrow margins when receipts are balanced against expenditures.

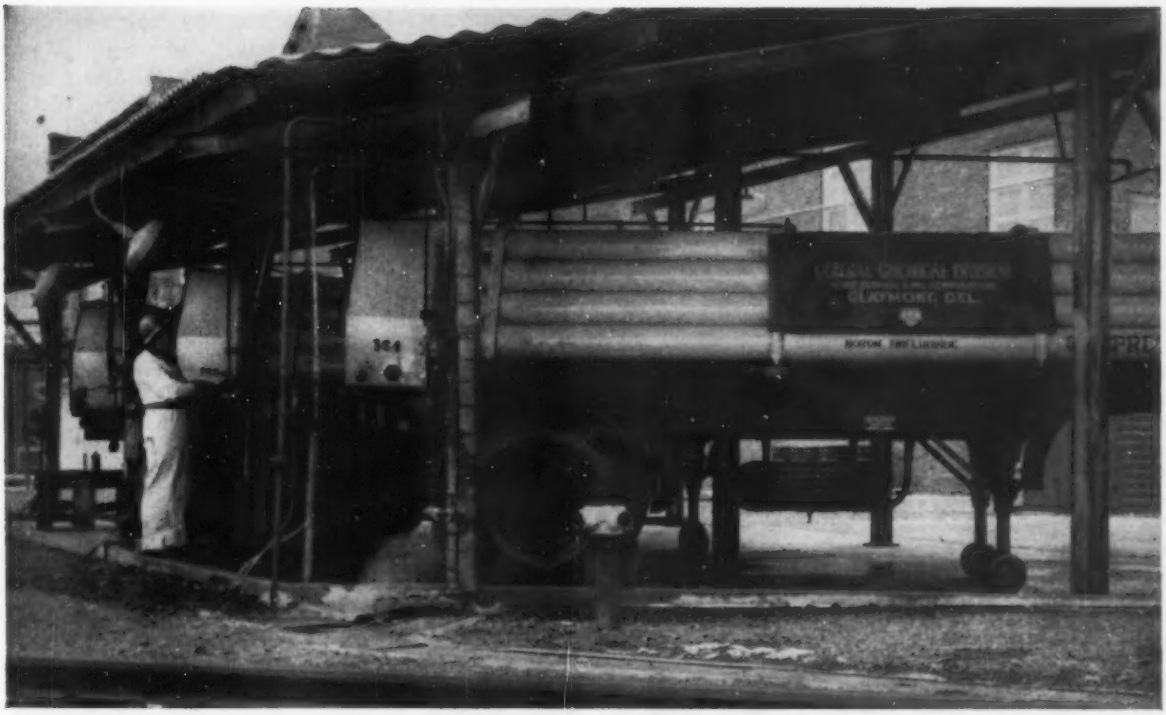
All of the following hike the costs of accidents. Do you consider them in the total?

1. Difference in productive ability of injured employe and his replacement.
2. Time lost by other employes who stop work out of curiosity, sympathy, or to assist the injured.
3. Time taken by foremen and executives assisting injured, investigating accident cause, and other paper work.
4. Time spent by first-aid attendants.
5. Increased costs of insurance rates when number of accidents increases.
6. Damage to equipment, tools, and materials.
7. Interference with production.
8. Costs under welfare and benefit systems.
9. Readjustment of employe even after he is back on the job full-time.
10. Profit loss by reduced productivity or idle equipment.
11. Drop in morale of fellow employes.
12. General overhead costs which continue.

Here, from detailed analysis of a number of thorough going accident cost systems, are presented twelve factors which enter into the cost of every refinery accident. Not only is it advisable that all be included from the standpoint of arriving at proper overhead figures but they will also serve to illustrate the profit in accident prevention measures.

The cost of lost time of the injured employe is a first item to be considered. Too often this is discounted as being primarily a loss to the individual rather than the company. The loss to the firm arises primarily in the absence of productive ability at that particular spot while the injured employee is away from the job. In only the rarest of cases are we able to find a replacement of equal skill and productive ability. A direct loss thus ensues (to the amount of difference in productive ability) between the injured employee and his replacement. This is invariably hidden in overhead figures unless searched out and recognized.

Curiosity and Sympathy. The cost of time lost by other employes who stop work out of curiosity, sympathy or to assist the injured individual at the time of the accident can often



How B&A® meets your needs for

BORON TRIFLUORIDE

Gas and Complexes

With large-scale production . . . Baker & Adamson has long been the leader in production of BF_3 gas—shipping this versatile catalyst in large trailer trucks like those you see being loaded above. B&A pioneered this method of shipment and today has a fleet of these trucks always on the road, serving the needs of the process industries.

With reference data . . . Baker & Adamson has compiled a considerable amount of reference data on the applications of Boron Fluoride gas and complexes. Boron Fluoride's wide range of applications and its cost-cutting production advantages—such as its ease of catalyst removal—make it a factor to be considered in almost any organic synthesis problem.

Mail coupon today—for technical data on properties and typical uses of B&A Boron Trifluoride gas or any of the complexes listed below. Attach company letterhead, please.

Boron Fluoride Ether (Diethyl) Complex
Boron Fluoride Phenol Complex
Boron Fluoride Diacetic Acid Complex
Boron Fluoride Di-n-Butyl Ether Complex
Boron Fluoride Dihydrate
Boron Fluoride Ethyl "Cellosolve" Complex
Boron Fluoride Hexamethylenetetramine Complex
Boron Fluoride Monoethylamine Complex
Boron Fluoride Para-cresol Complex
Boron Fluoride Triethanolamine Complex
Boron Fluoride Urea Complex

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☐ Please send general information on properties and uses of Boron Trifluoride gas ☐

_____ complex ☐

☐ Please send information on Boron Trifluoride for the following application:

_____

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Name _____

Position _____

Company _____

Address _____

City _____ Zone ____ State _____

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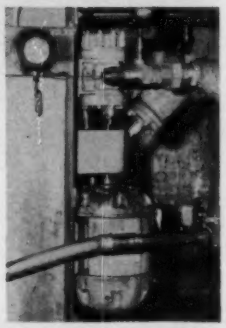
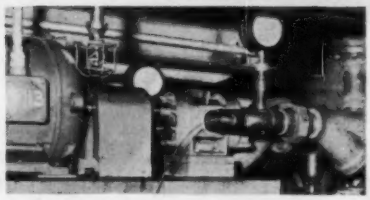


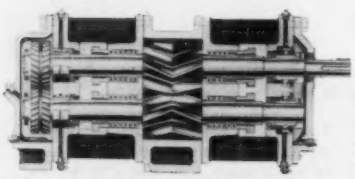
Drum-filling speeded up--wider range handled--costs cut with

Sier-Bath GEAREX®
ROTARY PUMPS

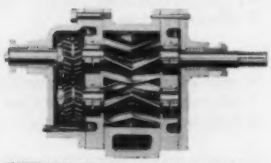
● A midwestern oil company installed a battery of Sier-Bath "Gearex" Pumps to replace the gravity feed method. Feeding capacity is now 90 gpm.—a wider range of viscosities and temperatures is handled—more drums filled per day, at lower cost. Pumps are installed in both vertical and horizontal positions according to space requirements, and provide dependable pumping 8 hours a day, 5 days a week.



***Sier-Bath* "Gearex" Pumps**



EXTERNAL GEAR & BEARING TYPE
for non-lubricating liquids



INTERNAL GEAR & BEARING TYPE
for lubricating liquids

Sier-Bath "Gearex" Pumps provide positive displacement, pulseless flow . . . quiet, vibrationless operation. Direct-connected up to 1800 RPM, they require no reduction gears. For high volumetric efficiency and long life there is no rotor-to-rotor or rotor-to-casing contact. Low pressure on stuffing boxes provides easy servicing.

Horizontal or vertical models to handle 32 to 500,000 SSU, 1 to 550 GPM at 250 PSI for viscous liquids, 50 PSI for water. Corrosion-resistant alloys, steam-jacketed bodies, water-cooled bearings, other adaptations to meet individual needs. See "Yellow Pages" for your local Sier-Bath Pump Representative or send for Bulletin G-2. *Sier-Bath Gear & Pump Co., Inc., 9261 Hudson Blvd., North Bergen, N. J.*

Sier-Bath ROTARY PUMPS

Screw Pumps | Gearex® Pumps | Hydrex® Pumps

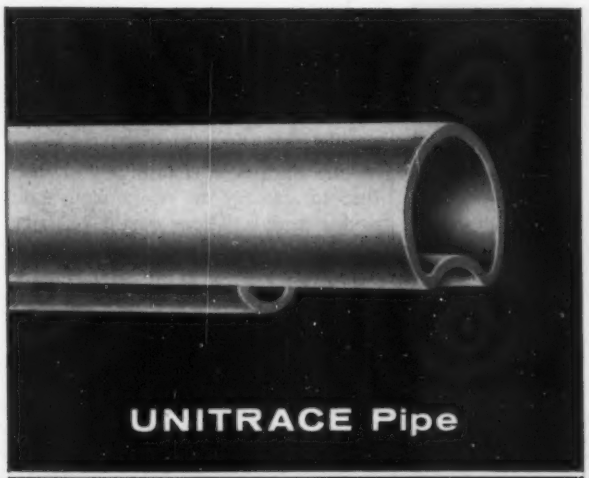
Founded 1905 — Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings — Member A. G. M. A.

amount to a more sizeable figure than would be revealed by a hasty look. Too often we tend to dismiss these as being of little consequence. Yet in the case of the average accident, such an interruption can last anywhere from a half hour to an hour and can involve from one to ten other employes. If only five are involved for a single hour the total wage outlay (and loss of production) involved with those five individuals will amount to a figure well enough worth adding to any accident cost analysis. On major accidents it is, of course, of far greater importance and can be of such a size as to seriously upset any departmental operating budget for that particular period.

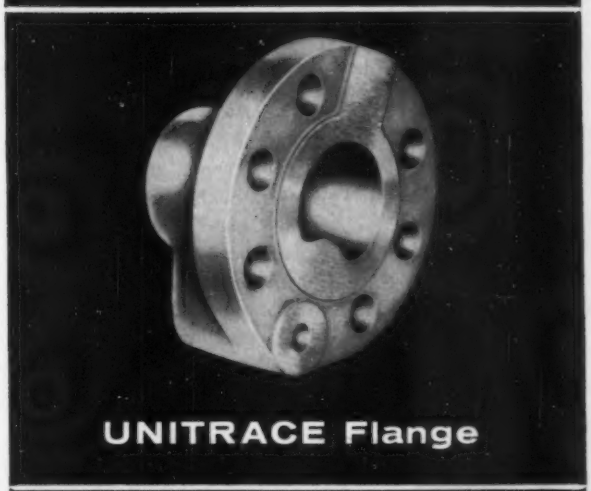
Third, we should figure and note the cost of time lost by foremen and executives to assist the injured employe, in investigating the cause of the accident, in arranging for someone else to take over, in training the new employe, in preparing reports and all of the other little things which are involved. Again we are dealing with a number of small things which standing alone cannot be particularly costly. However, when all are added together, the figure assumes very definite importance in our appraisal of the accident cost. Each of the points mentioned in the opening lines of this paragraph should be noted and evaluated. In addition, by study of procedures in past accidents, others of like nature pertinent to the individual operating techniques of your company will also make themselves apparent.

First-Aid Costs. The cost of time spent by first-aid attendants and staff when not covered by insurance should also be taken into consideration. Usually this is covered in the budget under a separate overhead classification. Nevertheless, whenever we are appraising the cost of an individual accident, the amount of first-aid involved in that particular accident should be calculated.

Increases in the cost of insurance caused by too many past accidents in our refinery should next be taken into account. As we well know, rates of all such types of insurance are based



UNITRACE Pipe



UNITRACE Flange

UNITRACE Trace Cap

Only **ALCOA** offers a complete new **UNITRACE** system

to cut costs and raise efficiency of steam-traced piping

Users of steam-traced pipe have found that valuable savings in cost plus greatly improved efficiency are automatic when they use ALCOA® UNITRACE. It provides steam and product passages extruded in a single unit of light, strong, corrosion-resistant aluminum alloy... completely eliminating the need for costly external steam jackets or inefficient tracer tubes. Now a new flange and trace cap provide fittings and connections designed for UNITRACE which are compatible with conventional piping. You can now design completely integrated UNITRACE piping systems and get all these benefits:

Low heat loss... high internal heat transfer
The recently introduced *round* configuration of UNITRACE makes possible most efficient internal heat transfer with minimum external radiation loss.

Easy, economical joints and connections
The special UNITRACE Flange mates with all 150-lb ASA flanged connections, permits use of standard flanged valves or other flanged connections. And the new UNITRACE Trace Cap permits quick, easy assembly of cross or tee connections.

Uses standard, preformed pipe insulation
The efficiency of UNITRACE often makes insulation unnecessary. When it *is* needed, standard preformed insulation can be used. UNITRACE saves extra dollars by employing smaller diameter insulation than conventional systems.

Excellent corrosion resistance
Thanks to the natural corrosion resistance of aluminum, UNITRACE is ideal for handling naval stores, molten sulfur, ammonium nitrate solutions, glacial acetic acid, fatty acids, tar, pitch, wax, urea, and similar products requiring heated transfer lines.

ALCOA UNITRACE and matching fittings are available in four standard pipe OD's: 1½", 2", 3" and 4". Get complete details on how you can use them to raise efficiency and lower cost on your own heated transfer lines. Call your nearest Alcoa sales office or write Aluminum Company of America, 905-H Alcoa Building, Pittsburgh 19, Pa.

Write for this FREE BOOKLET
This fully illustrated booklet contains complete engineering, specification and fabrication data on ALCOA UNITRACE. Write for your free copy!

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"ALCOA THEATRE"
Exciting Adventure
ALTERNATE MONDAY EVENINGS

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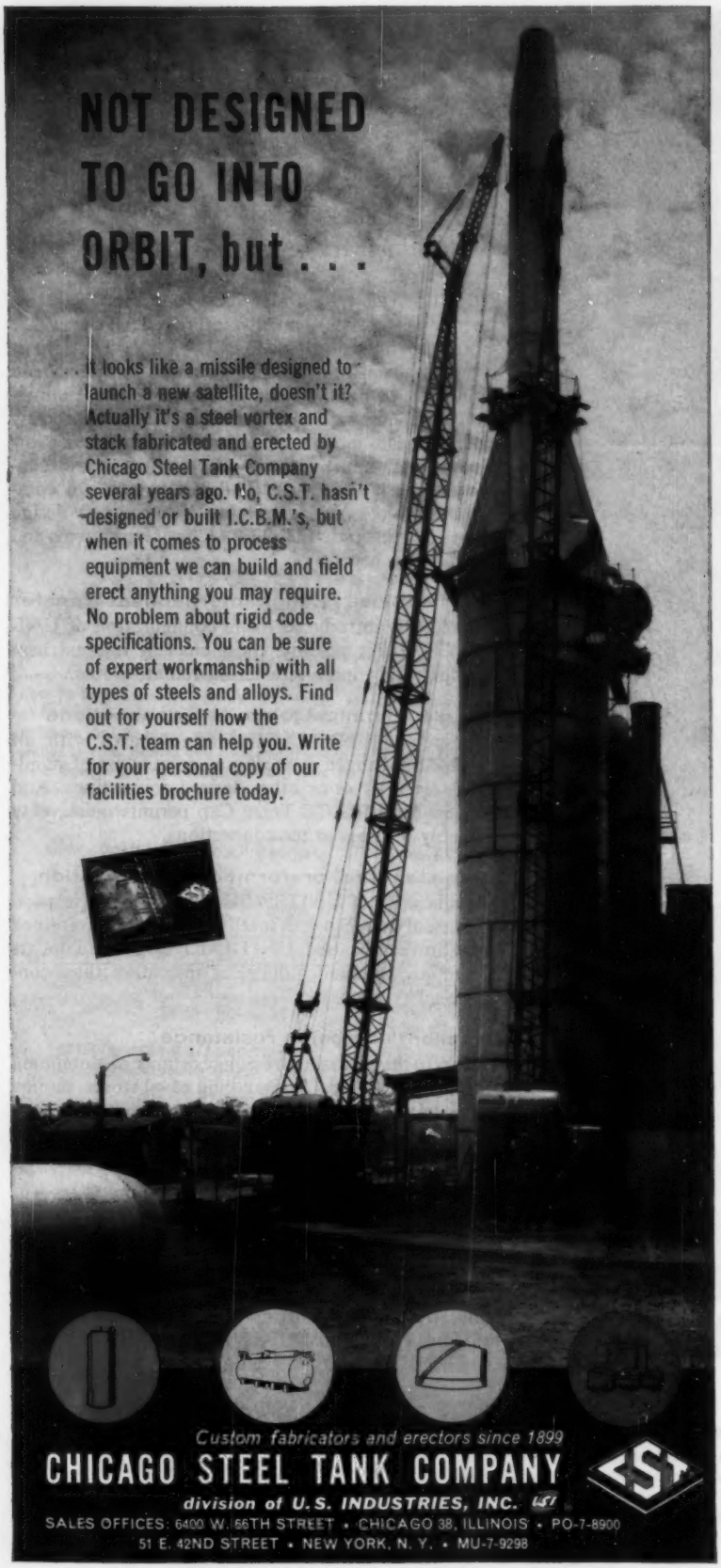
NOT DESIGNED TO GO INTO ORBIT, but . . .
. . . it looks like a missile designed to launch a new satellite, doesn't it? Actually it's a steel vortex and stack fabricated and erected by Chicago Steel Tank Company several years ago. No, C.S.T. hasn't designed or built I.C.B.M.'s, but when it comes to process equipment we can build and field erect anything you may require. No problem about rigid code specifications. You can be sure of expert workmanship with all types of steels and alloys. Find out for yourself how the C.S.T. team can help you. Write for your personal copy of our facilities brochure today.
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on the number and severity of accidents we have and that have occurred in our particular industry. As these mount, such insurance rates climb and definitely belong as part of any accident cost figures.

The sixth item should be the costs due to damage to equipment, tools and materials. There should be space on every accident report for notation of such damages. They are as definitely a part of the costs of any given accident as any outright expenditure of moneys may be involved.

Next we should appraise the costs due to interference with production, failure to fill orders on time, loss of bonuses, etc. Usually, unless the accident is of a very serious nature, the latter two may not be involved. If they are involved, however, we must make an accounting of them. The chief cost on routine accidents is in the first named—interference with production.

The cost to the employer under welfare and benefit systems also belongs in the accounting of individual accident costs; particularly so where we are making an earnest effort to arrive at a true figure for purposes of planning accident prevention programs in our refinery.

Readjustment Is Slow. We must also take into consideration, the costs of paying full wages to the injured employe after his return even though he will for a time be worth only a portion of his normal value at his job. Here is an all important factor generally overlooked in accident cost appraisals. Just as the firm has to lose in the inability of the replacement to meet the injured worker's production standards, so also must it suffer a loss until the latter is back in good health and full capability once again. In only the rarest of instances does this happen immediately regardless of the amount of time the injured worker has spent in recuperating. Even in full possession of strength and skill that man must readjust himself to the routine of his particular job and in some cases relearn skills which require continued day-in and day-out exercise to retain full productive ability.

Closely akin to this is the cost due to loss of profit on the injured em-

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CYANAMID ANNOUNCES
commercial production of new
AEROCAT® 2000
fluid cracking catalyst

This new catalyst, designed for "problem" operating conditions (such as heavy metals contamination) in catalytic cracking units, is now being produced commercially at Cyanamid's plants in Fort Worth, Texas and Michigan City, Indiana.

AEROCAT® 2000 Fluid Cracking Catalyst provides activity stability with greater economy than other low-cost catalysts. It offers an octane advantage, superior attrition resistance, and lower production of coke. AEROCAT 2000 has controlled bulk density for better fluidization properties.

Extensive testing on principal types of gas oils shows new AEROCAT 2000 to have outstanding catalytic properties. Because it is made under the same conditions of control in the same equipment as our other synthetic catalysts, it also has uniform physical properties. Ask your Cyanamid man for complete data on the new AEROCAT 2000.

Basic in Catalyst Chemistry

CYANAMID

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Originators of AEROCAT® Fluid Cracking Catalysts, AEROCAT TRIPLE A® High Alumina Catalysts, AEROFORM® Fluid Hydroforming and Platinum Reforming Catalysts, AERO® HDS Catalysts, AERO® Specialty Catalysts, CYPAN® Drilling Mud Conditioner, AEROLUBE® Lubricating Oil Additives, AERONOX® Antioxidants, AEROSOL® Surface Active Agents

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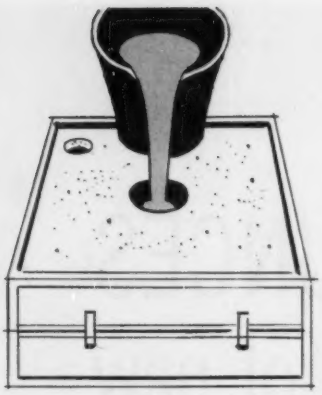

DUCTILE IRON CASTINGS

machine like cast iron, perform like steel

make possible substantial savings for many industrial users

Revolutionary Ductile Iron Castings are providing new cost-saving answers for design engineers everywhere. They provide the engineering advantages of steel and the processing advantages of cast iron. Their resistance to wear, shock or elevated temperature permits them to replace castings of more costly materials, and they may be cast to close tolerances in intricate thin-sectioned shapes to reduce machining time and trouble. Truly versatile, Ductile Iron castings are being used in hundreds of different applications.

Standard Brass, licensed manufacturer of Ductile Iron, is fully equipped to help you find economical solutions for your toughest parts problems. Our completely integrated facilities include: pattern, static casting, centrifugal casting, heat treating, machining and laboratory facilities. Write or call today for complete information on revolutionary Ductile Iron or Ductile Ni-Resist for exceptional corrosion and heat resistance.

Only Ductile Iron Castings Give You All These Properties

DUCTILITY
CASTABILITY
STRENGTH
MACHINABILITY
TOUGHNESS
HARDENABILITY
CORROSION RESISTANCE
PRESSURE TIGHTNESS

Trade Mark of the International Nickel Co.

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ployе's productivity and and on idle equipment. Both are important to the financial welfare of the refinery. Profits are based on worker productivity and continued operation of equipment in the refinery. When either drop so do the profits. Where they are lost at a particular spot because of an accident the amount involved definitely belongs in the analysis of cost of that accident.

Morale of Other Workers. We must also add the cost that occurs in consequence of the excitement or weakened morale of employes in that particular department due to the accident. Invariably where an accident has occurred (no matter how small) there will be such a drop in morale of other employes. Sometimes this is regained before the day ends but often it takes two or three days. The net result is invariably a drop off of production efficiency in the whole department until the accident is more or less forgotten and morale returns. All of this costs money to the refinery.

Finally, the overhead cost per injured employe insofar as general overhead is concerned, should be appraised and added to the total. This involves the expense of light, heat, rent and other such items which continue while the injured employe (and his production spot) remains non-productive.

Some of the foregoing, and perhaps in particular the last named, may seem inconsequential and unimportant. Standing on their own as sole cost factors in any given accident they may very well be so. But when we add all of them together, the final figure is never one we can brush off lightly.

Accidents cost dearly in any refinery—we never realize how much unless we make a complete analysis of their costs. When this has been done, we will be much more certain to give the accident prevention program full and complete support. Its importance will never be down graded by any individual from the department foreman or superintendent to the top executive of the refinery.

##

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customer reports prove

Big Savings with . . .

OCECO V-130 Conservation Regulators

Exclusive construction assures tight leak-proof closure fully up to operating setting — quick opening — and extremely high flows even at low pressures.

Oceco V-130 Conservation Regulators provide **greater flow capacity,** size for size, and pressure for pressure, **specially at low pressures** than **ever available before.** Our exclusive construction prevents vapors from escaping at less than set operating pressures. Positive flexing action of the membrane, held under tension, peels off and breaks away any icy formations, preventing freeze-ups. These valves bring never before secured **all weather** economy and dependability to the conservation of volatile products stored in cone, round, flat, lifter or expansion roof tanks. **Write for Bulletin No. 522. It gives full details!**

PRESSURE BALANCED CONSTRUCTION.

Tank pressures exerted on both sides of the pliable heat and cold resistant membrane keep membrane always under tension; —assuring tight seating fully up to operating setting— and positive flexing action that peels away icy formations preventing freeze-ups.

EXCLUSIVE OCECO FEATURE SAVES YOUR VAPOR DOLLARS!

THE JOHNSTON & JENNINGS CO.

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ENGINEERED
CRAFTSMANSHIP KEEPS
CLEVELAND
WIRE SCREENS
'way out in front

JOB CONTROL RECORD		
TIGHTNESS OF WEAVE		
ACCURACY OF CRIMP		
QUALITY OF METAL		
UNIFORMITY OF WEAVE		
WIRE THICKNESS		
SPECIFIED SIZE		
FLEXIBILITY		
DURABILITY		

TESTED AND APPROVED BY_____

THE CLEVELAND WIRE CLOTH & MFG. CO.

Successful processing depends on the ability of the wire screens to resist corrosion, abrasion and blinding. The accuracy of openings and proper selection of metals, woven to exact job specifications are controlled by expert craftsmanship and engineering supervision.

Filter segments and strainer elements can be fabricated to your individual job requirements. A wide range of weaves in all commercial metals and alloys such as stainless steel, monel, silver and copper are available.

We maintain a complete sample service department to take the guess work out of job specifications. Complete and descriptive bulletin files are available. Write or phone Diamond 1-1832.

Reference:
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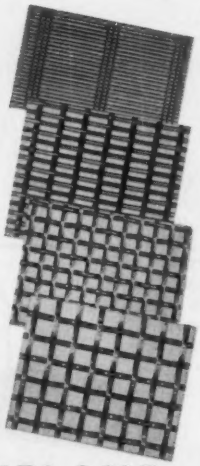
Thomas' Register
Conover-Mast
MacRae's Blue Book

Petroleum Refiner Catolog



The CLEVELAND
WIRE CLOTH & MFG. Co.
3571 E. 78th STREET - CLEVELAND 5, OHIO

If Oil Could Speak

If oil could speak it would have many fascinating truths to tell the non-oil public—truths that would win thousands of new friends for the oil industry.

But, oil can't speak—you can. You, as an individual, can win many new friends for the oil industry if you will pass the true facts on to your non-oil industry friends.

Here are some of those true facts. They are being presented for one purpose: To keep you posted on your industry, so you can tell the story oil is unable to relate.

Read these facts. You will find them informative—and interesting.

Why Is It Costing More to Find, Develop and Produce Oil?

Cost of finding oil. The increased cost of finding new oil is the result of (1) Increased exploratory activity per 1,000 barrels found, and (2) Increases in the unit cost of materials, equipment and labor.

In 1937-41, only 16 feet of hole were drilled for each 1,000 barrels of oil found in new fields; in 1942-51, the average was 44 feet; in 1952-56, 85 feet; in 1957, 99 feet. Result: It took about six times as much footage to find 1,000 barrels of reserves in new fields in 1957 as in 1937-41.

Development costs. In the five years prior to World War II, 35 feet of hole were drilled to develop 1,000 barrels of new reserves (including discoveries, extensions and revisions as reported by the American Petroleum Institute). In the 10-year period 1942-51, the average was 38; in the five year period 1952-56, the average was 61. In 1957, the footage was 86. These figures reflect the fact that new fields are generally smaller and deeper than those found in previous years.

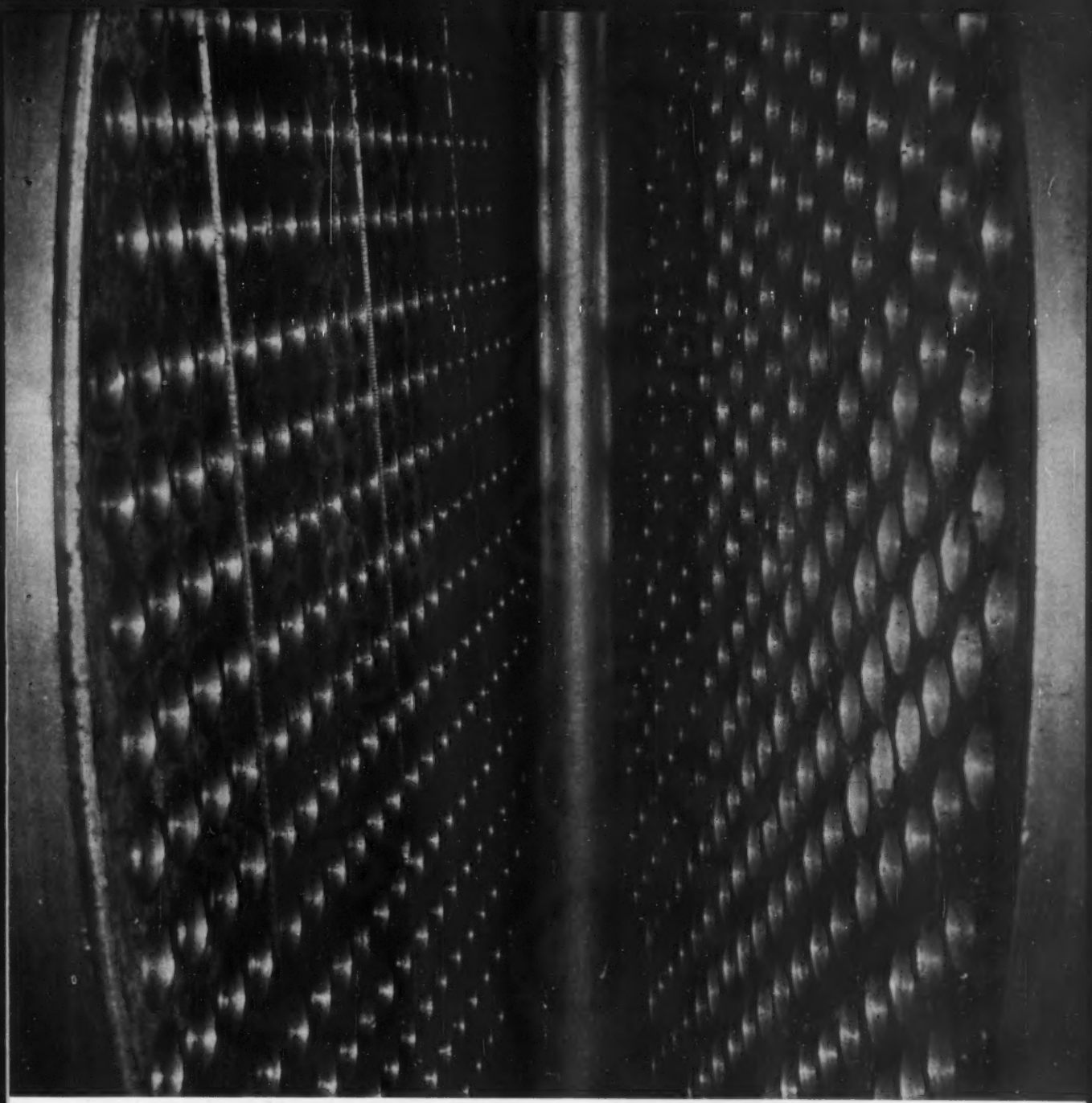
Increases in the prices of important development materials and equipment have contributed greatly to added costs. Some of those increases (1957, compared with 1953) are as follows: Oil field machinery and tools, up 22.5 percent; line pipe (carbon), up 42.5 percent; oil well casing (carbon steel), up 32.1 percent; oil well casing (alloy steel), up 43.1 percent.

Lifting costs. The largest single lifting cost item is production labor. Employment in production of crude totaled 347,700 in 1957—an increase of 16,000 over 1956 and nearly 50,000 over 1953. Hourly wages in crude production in 1957 were 18.1 percent higher than in 1953 and 5.2 percent higher than in 1956. Total payroll in 1957 is estimated to have been at least 10 percent above the 1956 payroll.

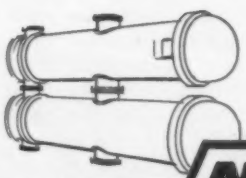
Cost of Maintaining Excess Productive Capacity.

For several years, the domestic oil industry has maintained substantial productive capacity in excess of actual production. Since 1954, this excess capacity has ranged from 1.5 million to a current 3 million barrels per day. The industry's investment in this standby capacity is substantial, and the interest on this investment, together with taxes, maintenance etc., represents economic costs of considerable magnitude which are not included in the foregoing cost classifications.

For more data on advertised products, use Readers' Service Cards, last page.



READY TO ROLL from storage racks to bundling jigs, these heat exchanger tube sheets symbolize the assembly-line techniques developed by The M. W. Kellogg Company to speed fabrication, yet still adhere throughout to the highest standards of design and engineering. To assure the optimum in heat transfer equipment for petroleum refinery and chemical plant service, call Kellogg's Fabricated Products Sales Division.



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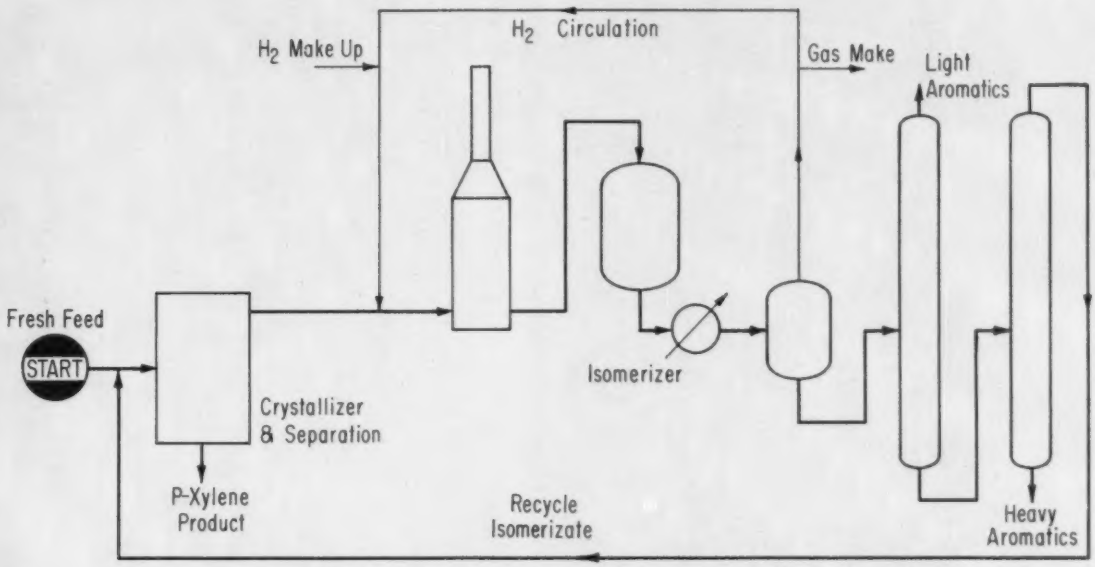
What's Happening . . .

. . . in the Industry



Special separation coupled with Catforming catalyst produces paraxylene from a C_8 aromatic charge.

Octafining—New Process for Isomers

Atlantic gives new name to reforming process which produces aromatic isomers.

OCTAFINING is the name given Atlantic Refining Co.'s new process, which preferentially produces only one isomer from a C_8 aromatic charge. The process is the combination of basic Catforming and a special separation method which isolates the desired isomer.

The separation method that is used depends on the type of isomer to be separated. In the case of paraxylene, a low temperature crystallization process is employed. The material from which the isomer has been removed is then charged through the Octafiner catalyst bed to re-establish the equilibrium distribution of the isomers. Again, the desired isomer is stripped from the effluent. By continuing this cyclic treatment, almost all of the other isomers may be converted to the desired one.

The attention given this new process stems from the continued interest in the various aromatic products. For example, ethyl benzene is used in styrene production, orthoxylene for phthalic anhydride, metaxylene for isophthalic acid, and paraxylene for terephthalic acid. The new process permits shifting the relative production of these isomers to correspond to the current demand of each.

TABLE 1—Xylene Isomerization with Catforming Catalyst

	Feed To Isomerization Vol. Percent	Total Isomerisate Vol. Percent
Ethyl Benzene	10.0	6.1
o-Xylene	29.4	23.3
m-Xylene	48.4	38.4
p-Xylene	7.5	18.7
Light Aromatics	2.5	6.1
Heavy Aromatics	2.0	4.6
Non Aromatics	0.2	2.8
p-Xylene in C_8 Aromatic	7.9	21.6

The first commercial application of Octafining will be made in Iwakuni, Japan. There the Mitsui Petrochemical Industries, Ltd., is installing a unit to make paraxylene for an intermediate to synthetic fibers production. Completion of the plant is expected in the summer of next year.

The following is a brief run-down on the important features of the Octafining process:

Charge—The charge to the Octafiner is C-8 aromatics of 95 plus percent purity.

Product—Depending upon the separation technique used, various xylenes can be produced. In this case p-xylene is the product.

Description—The sequence of steps

Some of the 150 Foxboro Dynalog Recorders used at Rocketdyne's Propulsion Field Laboratory. During each test, these instruments log critical items of information with split-second timing and exacting accuracy.

where accurate, dependable records are a MUST

ROCKETDYNE looks to DYNALOG* Electronic Recorders

Test-firing is a vital function at Rocketdyne, a division of North American Aviation, Inc. Rocketdyne manufactures liquid propellant rocket engines for the Army's Redstone and Jupiter missiles; the Air Force Atlas and Thor.

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Dynalogs fit Rocketdyne's instrument requirements to a T: accurate within ±¼% of full scale, one second pen sweep, high input impedance. And because Dynalogs have no slidewire, Rocketdyne finds their maintenance problems practically eliminated. They prefer circular charts also, for faster, easier analysis of each measured variable after a test firing.

Rocketdyne is presently using over 1,000 Dynalog Recorders. Find out how Dynalog Instruments can improve recording and control of your process. Write for Bulletin 20-10.

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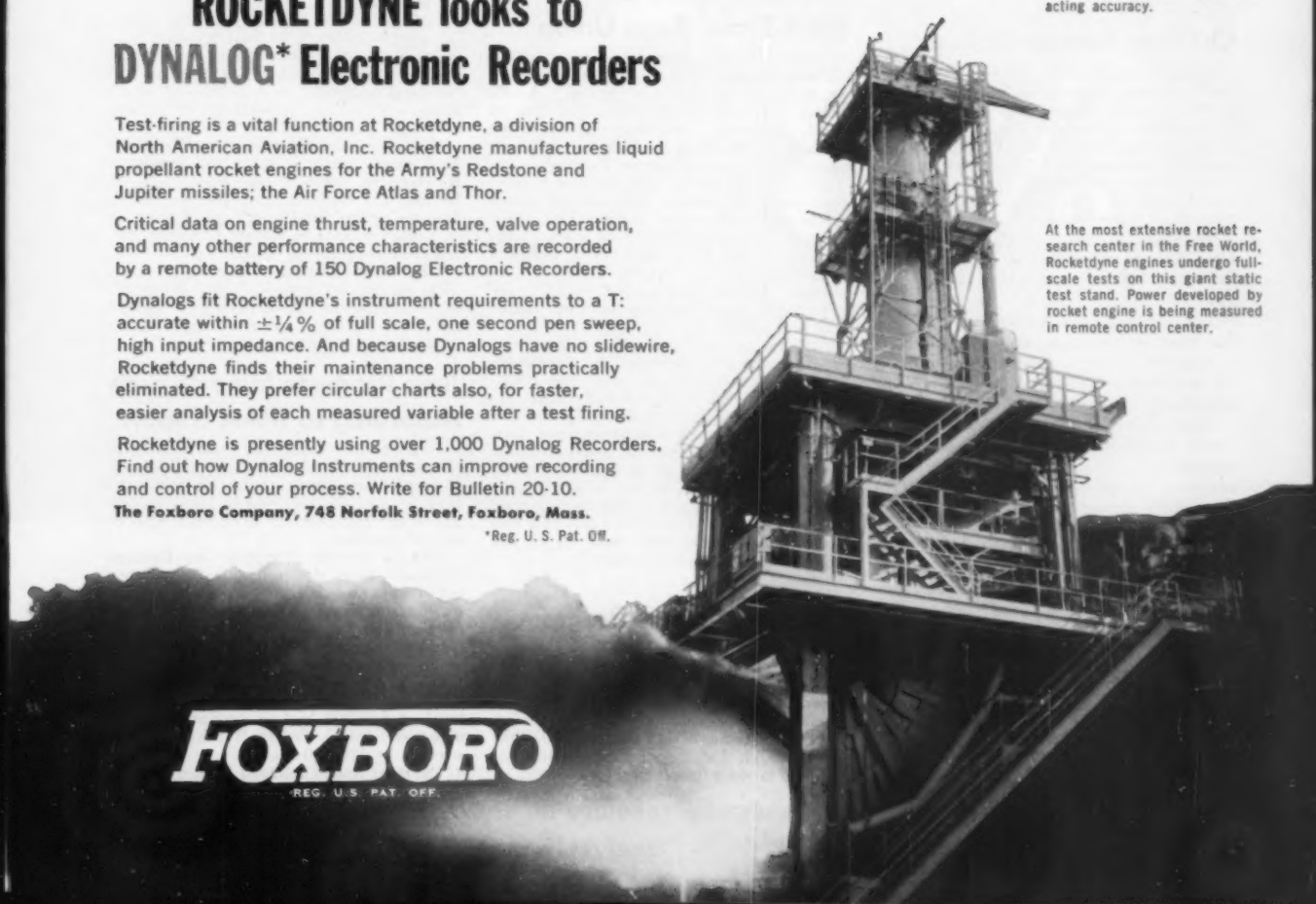

At the most extensive rocket research center in the Free World, Rocketdyne engines undergo full-scale tests on this giant static test stand. Power developed by rocket engine is being measured in remote control center.

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for the production of p-xylene is shown in the flow diagram. A fresh feed of C-8 aromatics combined with recycle from the isomerization process is stripped of p-xylene by a conventional low temperature crystallization and separation process. The stripped effluent is charged to the Octafiner along with recycle hydrogen and sufficient fresh feed hydrogen to balance the operation. The isomerization step is a simple single reactor operation carried out at about 200 psig. Once-through yields are shown in Table 1. Notice that the production on p-xylene essentially reaches equilibrium and that side reactions are at a minimum. The total effluent from the isomerizer is condensed, hydrogen separated from recycle and the condensate separated in conventional fractionation equipment to remove light and heavy products.

By substituting alternate separation techniques the yields of specific aromatics other than p-xylene can be maximized.

Operating Conditions—Reactor temperatures range from 750 F. to 900 F. Pressures are 150-350 psig.

Commercial Installations—Mitsui Petrochemical Industries, Ltd., Iwakuni, Japan, (under construction).

References—Proceedings of the Fourth World Petroleum Congress, Section III/D, Paper 3.

Industrial and Engineering Chemistry, Vol. 47, page 770, April 1955.

Octanes Remain Stable

Gasoline on sale at service stations in July showed national weighted averages of 98.5 octane number for premium and 91.2 octane number for regular, according to the latest monthly survey of antiknock quality compiled by Ethyl Corp. Both averages were unchanged from June. Compared with a year ago, both averages were 0.3 octane number higher.

Average tetraethyl lead contents in June were 2.49 ml per gallon of premium gasoline and 1.83 ml per gallon of regular gasoline.

For companies marketing more than one grade of premium, the survey showed a range of 100.4 to 102.8 octane number for the highest grade, on the basis of 40 samples in 20 cities.

Thirty-three of the 57 cities in Ethyl's survey reported increases over June in the average octane number of their premium gasolines, one by 0.5 octane number. Thirteen cities reported decreases while 11 cities were unchanged. In regular gasoline, 27 cities reported increases over May in their average antiknock quality. Eighteen cities reported decreases while 12 cities were unchanged.

Compared with the nationwide premium average of 98.5 octane number, 11 cities reported premium averages of 99 octane number or higher. In regular gasoline, 17 cities showed average octane ratings of 92 octane number or higher, compared with the national weighted average of 91.2 octane number.

Socony Gets Vast Computer Network

A world-wide network of electronic computers, linked by "transceivers" and other rapid means of communication, is being developed by Socony Mobil Oil Co., Inc. Already the new network is being used to help solve many company problems—everything from how far apart to space oil wells to possible shifts in the product-distribution patterns for Europe, West Africa, and the U. S.

The computer network, in the making for three years, was announced July 16 as trials were completed for two of its important new elements, a computer at Socony is New York hearquarters, and a transceiver hook-up connecting it with the company's research laboratories and refinery at Paulsboro, N. J.

The transceiver transmits electrical impulses by wire. These impulses, received in New York on punch cards, provide the computor with data on the type of crude oil in Paulsboro, the types of products desired, and other pertinent information. Back to Paulsboro go the computer's recommendations on the best use of the refinery's facilities. The whole procedure takes about five minutes, compared with the old manual method which took two men half a day, according to the company. The computer reportedly makes more elaborate calculations, ones that weren't possible by hand.

The $2 million computer is the principal data-processing machine in the company's electronic computer center. Grouped with it is a smaller one, punch card accounting equipment and an electronic printer. Occupying more than 10,000 square feet of floor space, the computer center processes data from Socony offices and affiliates all over the world. This includes material that has been pre-processed by other computers at the Dallas offices of Magnolia Petroleum Co. A similar arrangement is being developed with General Petroleum Corp., a Socony affiliate, which has a computer in Los Angeles. Generally, data from outside New York is sent by air to the computer center on punch cards.

Socony is currently attempting to express the operations of its refineries as mathematical equations which can be cranked into the computer. Each refinery's operations, it has been found, can be represented by some 200 or more equations. Once this pattern is established, the computer data can be used by refinery people to control quality.

Union Oil Co. of Calif. is another with a data transceiver in operation between its refinery and home office. The Union unit has a capacity of 11 cards per minute. With each card having 80 digits, it means that 880 digits can be transmitted and reproduced. The system is self-checking to assure that the reproduced card is identical to the original.

Oleum refinery is using the system to calculate projected inventories, using such data as current inventories, projected crude runs estimated market demands, and unit operating schedule. All of these factors must be considered in calculating the projected inventories.

Plenty of Shale Oil For Hard Times, Says Union

"America need no longer be dependent on foreign sources for esssential crude oil in time of national emergency," A. C. Rubel, president of Union Oil Co. of Calif., said after reviewing results of his company's $9 million shale oil research operations in northwestern Colorado.

"Union Oil Co. is in a position to produce shale oil and its products for armed forces and civilian use under a crash program if foreign oil is shut off by such incidents as the Suez crisis or a political disturbance in the Middle East," he reported. "All the time needed would be for steel fabrication and assembly of plants and pipe lines.

"Operating data are quite a bit ahead of our economic analysis," he explained. "Preliminary figures are most significant. On the basis of a 25,000-bpd plant, delivering semi-refined products to the Pacific Coast or comparable areas, costs compare favorably with similar products made from natural crude oil at prices presently posted for such crudes. But in many cases crude oil is selling for less than posted prices. Under normal conditions this would indicate that with shale oil we are approaching competitive costs."

Standard Installs Program To Up Refinery Efficiency

Standard Oil Co. (Indiana) has set up a new program to improve efficiency and economy of operations at its refineries. Five senior scientists of Standard's Whiting Research Laboratories have been appointed to coordinate the application of research to different aspects of refining at all locations.

At each location, chemists and chemical engineers work in collaboration with operating men to solve technical process problems encountered. Beyond coping with the local situation, ideas developed at one place can benefit operations at another refinery.

The new coordinators are: **Claude O. McKinney**, catalytic cracking; **Waldemar R. Hertwig**, catalytic reforming; **John H. Lovett**, alkylation and polymerization; **Moses Gordon**, final treatment of gasolines and other fuels; and **Robert J. Austin**, control and recovery of wastes.

Charles R. Harte, coordinator of technical service for Standard, will direct the over-all program. Additional coordinators for other areas of interest may be appointed as needed.

June Products Imports High According to IPAA Report

Imports of unfinished oils increased about 100,000 bpd to bring total imports of petroleum products to an unusually high level of 650,000 bpd in June, according to the Independent Petroleum Association of America.

IPAA's monthly "Supply and Demand Outlook" finds that schedules by importing companies indicate product imports during the third quarter, July-Sept., will be near the June level unless reduced under the voluntary imports program.

The June level of 125,000 bpd of unfinished oil imports compares with an April level of 28,000 bpd. The June level level of 650,000 bpd of products imports compares with "normal" third-quarter average of 425,000 bpd.

Other estimates released by the Associa-

NICOMO 1.

A new hydrogen treating catalyst

leads the way!

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more desulfurization

No other hydrogen treating catalyst desulfurizes as well as new NICOMO 1. (NICOMO 1. maintains a commercially-proved 8% superiority in desulfurization activity.) No other catalyst offers such a major cost saving. (Because of lower bulk density, you need fewer pounds of NICOMO 1.) Full information in a new booklet. Write on company letterhead for your copy. Or see The Man From Davison.

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CORROSION RESISTANT METAL INSTRUMENT LINE HARNESS

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Dekoron Metl-Cor is a multiple tube bundle of copper or aluminum tubes over which is extruded a thick sheath of corrosion-proof plastic. This harnessed construction means that it costs much less to install than ordinary metal tubing because many tubes are installed at one handling. Metl-Cor instrument line harness is available with from 2 to 19 (7 *illustrated*) tubes per bundle, up to 1000 ft. in length.

Corrosion resistance . . . elimination of tubing replacements . . . ease and speed of installation—*no other metal instrument tubing can compare with patented Dekoron Metl-Cor*. Request Bulletin 456 for additional information.

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research
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DEKORON PRODUCTS DIVISION

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tion: domestic crudes should average 7-million bpd during August-October period, 500,000 bpd above the anticipated average daily production in July of 6½-million bpd; domestic consumption during August-October period should average 8½-million bpd; exports will be down 100,000 bpd from last year.

IPAA President Predicts Big Petroleum Need Coming

An increase of more than one million bpd in petroleum supply requirements during the winter of 1958-59 over the current, June 1958 supply was predicted recently by Minor S. Jameson, Jr., executive vice president, Independent Petroleum Association of America.

Jameson made the statement in a report on "The Demand For U. S. Crude Oil" before the final general session of the Interstate Oil Compact Commission at the Hotel Utah. He praised the Commission as "the outstanding example of cooperative work by state governments in the field of conservation," and noted the effect of ever-changing relationships between supply and demand on state conservation practices.

Summarizing the current situation, Jameson attributed reduced domestic crude oil production primarily to increased imports and inventory corrections. He said that excepting West Coast inventories, however, "further inventory corrections should no longer be a factor in the market for crude oil in other domestic areas during the months ahead."

The outlook for the demand for U. S. crude oil during the six month heating period, October, 1958 through March, 1959 was based on the demand forecasts in the IPAA Supply and Demand Committee report of April, 1958 brought up to date. Jameson noted that requirements for U. S. crude oil during the forecast period will depend on the production of natural gas liquids and on the volume of foreign oil imported into the United States.

Concluding his remarks, Jameson said "Although the demand outlook for U. S. crude oil shows a substantial increase over recent and current depressed levels of production, a world surplus of oil continues to pose serious and difficult problems from the standpoint of both national policy and state conservation programs."

Petrochemicals Make Roads Safer and Stronger

A new safety pavement, made of plastic, was demonstrated recently on the heavily traveled San Francisco-Oakland Bay Bridge. It resists skidding even when it is wet, and stops cars in one-half to three-quarters of the distance required by cars stopping on concrete.

The material is a plastic adhesive called Guardkote paving resin by its developer, Shell Chemical Corp. It is poured on concrete or asphalt and covered with grit as is begins to harden. The result is a thin, sand-like coating stuck firmly to the road.

In a demonstration of the material's adhesive strength, a Shell engineer glued a steel plug to the road with Guardkote and tried to pull it loose with a jack. The concrete broke first. A slug of it came

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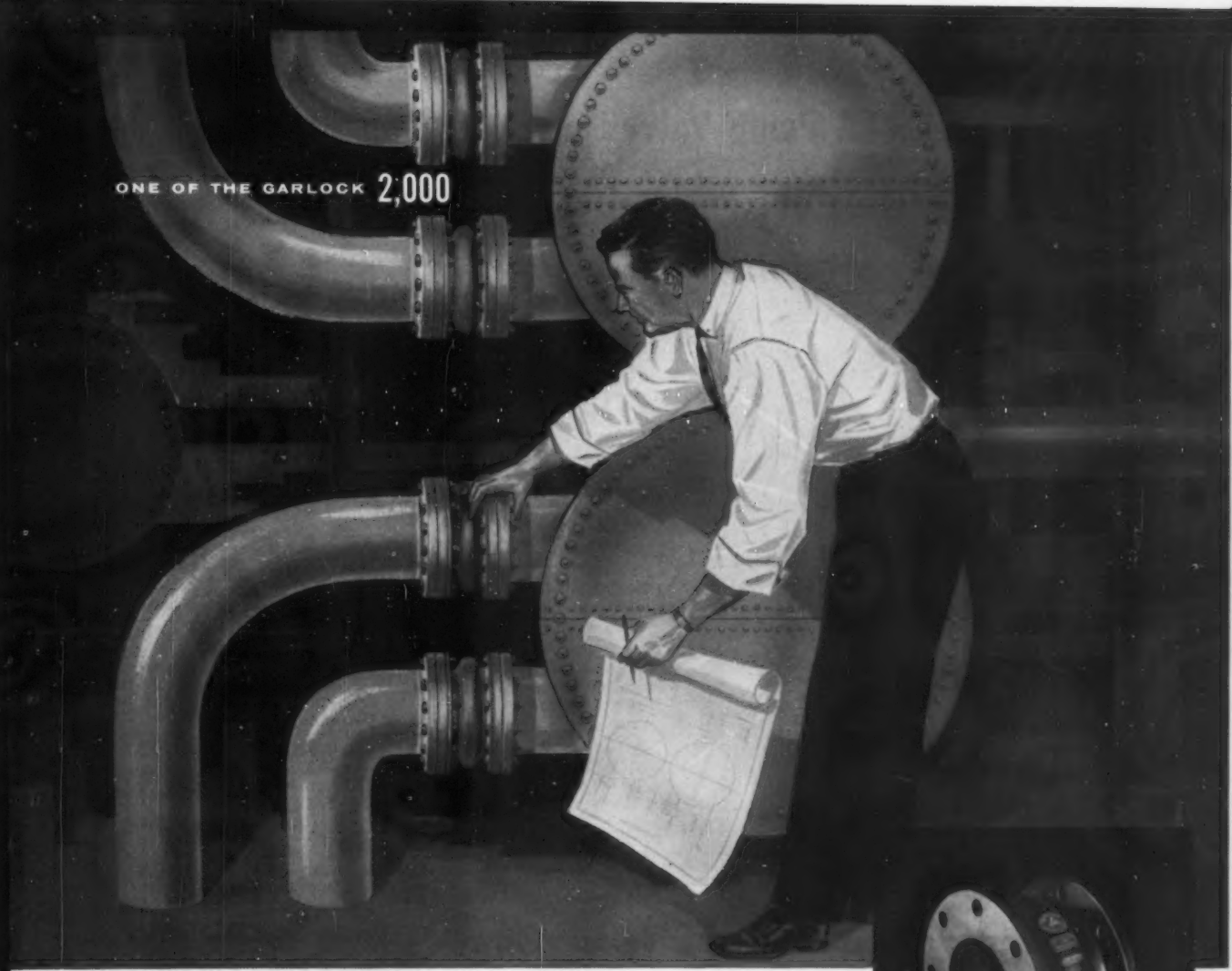

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2. **ELIMINATE VIBRATION AND NOISE.** Pumps, compressors, engines, and pressure surges in pipe lines create vibration and objectionable noises. Garlock Rubber Expansion Joints act as an absorbent cushion . . . reduce vibration and insulate against transfer of noise to other parts of the building.
3. **COMPENSATE FOR MISALIGNMENT.** Piping and mechanical equipment often moves out of normal alignment during operation due to wear, load stresses, or settling of buildings. Garlock Rubber Expansion Joints compensate for this and prevent possible breakdowns of equipment. They also make installation easier since alignment of piping and equipment need not be quite as accurate when expansion joints are used.
4. **REDUCE FLANGE BREAKAGE.** Undue stress caused by misalignment, vibration, expansion or contraction of piping or equipment, will break the metal connecting flanges. Garlock Rubber Expansion Joints relieve such stresses.

AND, remember Garlock Rubber Expansion Joints outlive metal ones . . . do not crack, corrode, lose shape, or require gaskets. Moreover, rubber joints withstand higher pressures too. Available for pressures up to 125 psi. Maximum service life at temperatures to 180° F. Get complete data on this important member of "the Garlock 2,000" . . . two thousand styles of packings, gaskets, and seals for every need. See your local Garlock Representative or write for folder AD-137.

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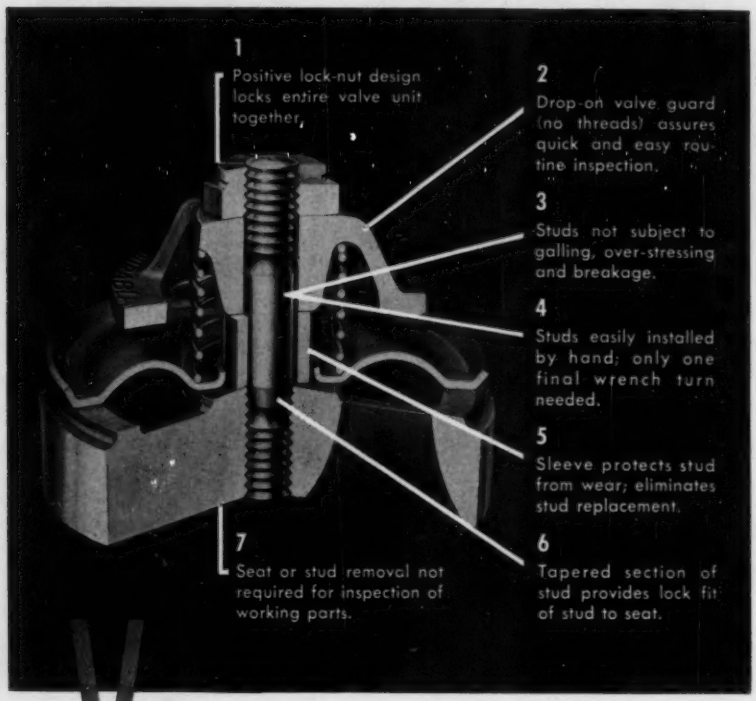
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Positive lock-nut design locks entire valve unit together.
2
Drop-on valve guard (no threads) assures quick and easy routine inspection.
3
Studs not subject to galling, over-stressing and breakage.
4
Studs easily installed by hand; only one final wrench turn needed.
5
Sleeve protects stud from wear; eliminates stud replacement.
6
Tapered section of stud provides lock fit of stud to seat.
7
Seat or stud removal not required for inspection of working parts.

New V-design assures even greater dependability

You want *maximum valve dependability* for your reciprocating pumps . . . and DURABLA gives you just that in the new V-7 unit.

Incorporating seven points of superiority, the new valve features a tapered or V-shaped stud which screws down tight to the seat. This exclusive design anchors the stud, eliminating any possibility of galling, over-stressing or breakage. What's more, the new self-locking nut and drop-on guard assure quick and easy inspection of working parts—without stud or seat removal.

Remember: In the DURABLA Valve, only "point contact" is made by the valve member on the stud sleeve, so it can't bind or hang-up. The open-type guard assures free flow of liquid, prevents clogging.

These stainless-steel valves operate freely under temperature extremes, with corrosives, and in any position. Made in 15 sizes to fit any reciprocating pump, old or new.

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Keep your pumps fit with the valves that fit all pumps.

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loose, still bonded to the steel plug.

The initial use of the material will probably be at toll booths and on dangerous grades and curves where traffic has worn road surfaces smooth and made them slick with oil, according to the company.

The skid-proofing surface will stand up under heavy traffic and it resists acids, deicing chemicals, oil and other chemicals that erode concrete. The product grew out of Shell's research in EPON (R) resin which led to a cooperative road surfacing program with Reliance Steel Products Co. In their adhesive form the resins will bind objects such as glass to glass and metal to metal, and have replaced rivets in some jet planes. As plastics they can be shaped into metal-forming dies, tools, glass-laminated telephone poles and other high-strength products.

Change of Venue to Tulsa Sought by Oil Companies

U. S. District Court will hear argument Sept. 10 on a motion for change of venue filed by 29 oil companies charged with conspiring to raise crude and gasoline prices during the Suez crisis. The defendants want the case moved to Tulsa. They contend that because of the geographical spread of the defendants, Tulsa would be more convenient, and that to face trial in Alexandria, Va., would impose "undue hardship."

Twenty-five of the defendants, or their affiliates, have offices subject to the jurisdiction of the Oklahoma court. Seven of them have home offices there.

Tidewater Sets Record with Delaware Plant Coking Unit

Tidewater Oil Co. claims the world record for continuous operation of a fluid coking unit. The company said the 42,000-bpd unit at its Delaware plant achieved a 300-day first run operation, processing 7-million barrels of vacuum residuals that would otherwise have been marketed in 10-million barrels of heavy fuel oil. The unit is now shut down for a turnaround.

Cause of Hancock Fire Still A Mystery

Exact cause of the Hancock Oil Co. refinery fire at Long Beach, Calif., still has not yet been determined. Intense heat of the fire created extensive damage, making accurate analysis impossible until all reports and surveys have been completed.

Company employees currently are engaged in clean-up work. Badly damaged major process machinery and equipment, including pumps, motors, turbines, blowers and exchangers, are being removed for detailed metal inspection and determination of the extent of damage. Fire damaged structural steel and pipe is being sold to salvage and scrap dealers.

Although a substantial portion of the refinery and its tankage was destroyed when fire struck the plant last May 22, inspection has revealed that the Ultraforming unit, the company's latest and most modern addition to the refinery, escaped serious fire damage. The major

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WASHINGTON, D. C., NATIONAL AIRPORT

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AIRCRAFT CRASH RESCUE TRUCK
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Fire trucks get the benefit of famous Rockwood nozzles and proportioning systems producing WaterFOG, FogFOAM, FOAM and WET — each designed to conquer different types of fires. By means of Turret Nozzles, these trucks discharge large volumes of FogFOAM, FOAM or WaterFOG. By means of Ground Sweep Nozzles, they fight flowing gasoline fires and protect firefighters and trucks at the same time. By means of Hand Lines, they control fires in hard-to-get-at areas.

If you want precision fire fighting products — by all means send for Rockwood's free booklet. Just fill in and mail the coupon at the right now. Rockwood products have been tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal industrial areas.

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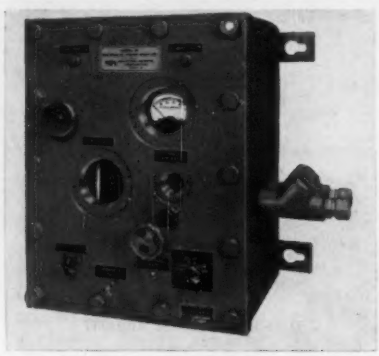

Model W Electrolytic Moisture Analyzer
Explosion-Proof Model

Measures water content better than 1 part per 1,000,000!

Some Useful Applications:

- Continuous or batch analyses of water in a wide variety of gas and liquid streams—including process streams, inert atmospheres required in plant processes and laboratory dry boxes, and plant instrument streams.
- Measuring reaction rates where water is involved as a reactant, product, or catalyst.
- Studies of moisture permeability of polymers.

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Hatboro · Pa.

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processing unit, the TCC unit, suffered an estimated 30 percent damage.

Redesign of refinery tankage to provide more modern and efficient handling of products is in the planning stage. Exact completion date for the rehabilitation work has not been set inasmuch as clean-up work may be combined with construction activity.

A consulting engineering firm has been retained to assist in the formation of long-range plans for the company. Working with the consultants are two engineering firms, Ralph M. Parsons Co., Los Angeles, construction engineers for the rehabilitation program, and C F Braun Co., Alhambra, estimators of the extent of the fire damage to apparatus, machinery and equipment.

Fungus Spray Developed

Fungus-fighting oil spray is being applied to banana plants as a fine mist.

The fungicide, and the technique of applying it, were developed in a joint research program by Esso Research and Engineering Co. and Esso Standard Oil, S.A. Their work was based on initial experiments with petroleum sprays, undertaken in 1954 on the island of Guadalupe.

Less than two gallons effectively cover one acre of plants. Helicopters and fixed-wing planes can spray 50 to 80 acres an hour. On small banana farms, portable knapsack-sprayers can be used to protect an acre in 10 or 15 minutes.

IPA President Predicts Boom in Petroleum Products

Minor S. Jameson, Jr., vice president of the Independent Petroleum Association, told the Interstate Oil Compact Commission recently that the need for new petroleum supplies will increase by more than one million barrels by the October-March period. He added that domestic demand will likely average one billion bpd during the six-month heating season. That would be a 230,000-bpd increase over the like 1957-1958 period.

About 430,000 bpd can be accounted for through seasonal withdrawals from product inventories, Jameson said. This would leave a required new supply of 9.5 million bpd, an increase of 3.2 percent over the 1957-1958 heating season.

U. S. crude oil could account for about 7.1 million bpd of new supply during the coming heating season, provided imports are held at current levels. Imports of crude and products would total about 1.5 million bpd, and natural gas liquids about 855,000 bpd.

Jameson noted that the estimated crude production demand compares with a current rate of about 6.3 million bpd.

– Changing Times –

Lammot duPont Safety Awards were received by U. S. Rubber Co., Royce Chemical Co., and Tennessee Corp. during the 86th annual meeting of the Manufacturing Chemists' Assn., in June.

Jefferson Lake Sulphur Co. is setting up new firm, Jefferson Lake Petrochemicals of Canada, Ltd., to take over its Canadian Inventory and assets, mostly in British Columbia and Alberta.

Two coffee-for-oil deals with Iron Curtain countries reportedly are under negotiations in Brazil. Government officials have indicated privately that dollar shortage and coffee surpluses make dealings with Iron Curtain countries certain.

Soviet Russia was principal buyer of Uruguayan products during first quarter of 1958, according to Montevideo newspaper "El Pais." **The country plans to receive 200,000 tons of Russian crude this year.**

U. S. Tariff Commission reported that **total output of crude products from petroleum and natural gas in 1957 was largest on record,** 1 percent higher than 1956.

Esso Research and Engineering Co. has moved to the Esso Research Center, 1600 E. Linden Ave., Linden, N. J. All shipments destined to arrive after August 15 should be sent to this address.

Safety record of 16,573 man-days free of accident in one month has been achieved by Canadian Kellogg during construction of British American Oil's Vancouver refinery. **Record won British Columbia Centennial Safety Award Certificate,** presented by British Columbia's minister of labor.

Controlling interest in Grand Central Rocket Co., Redlands, Calif., has been transferred to Petro-Tex Chemical Corp. by Tennessee Gas Transmission Co., who owns 93.4 percent of the firm.

Principal terms of an **agreement to merge Crescent Petroleum Corp., and Norbute Corp.** have been approved by the boards of directors of both companies.

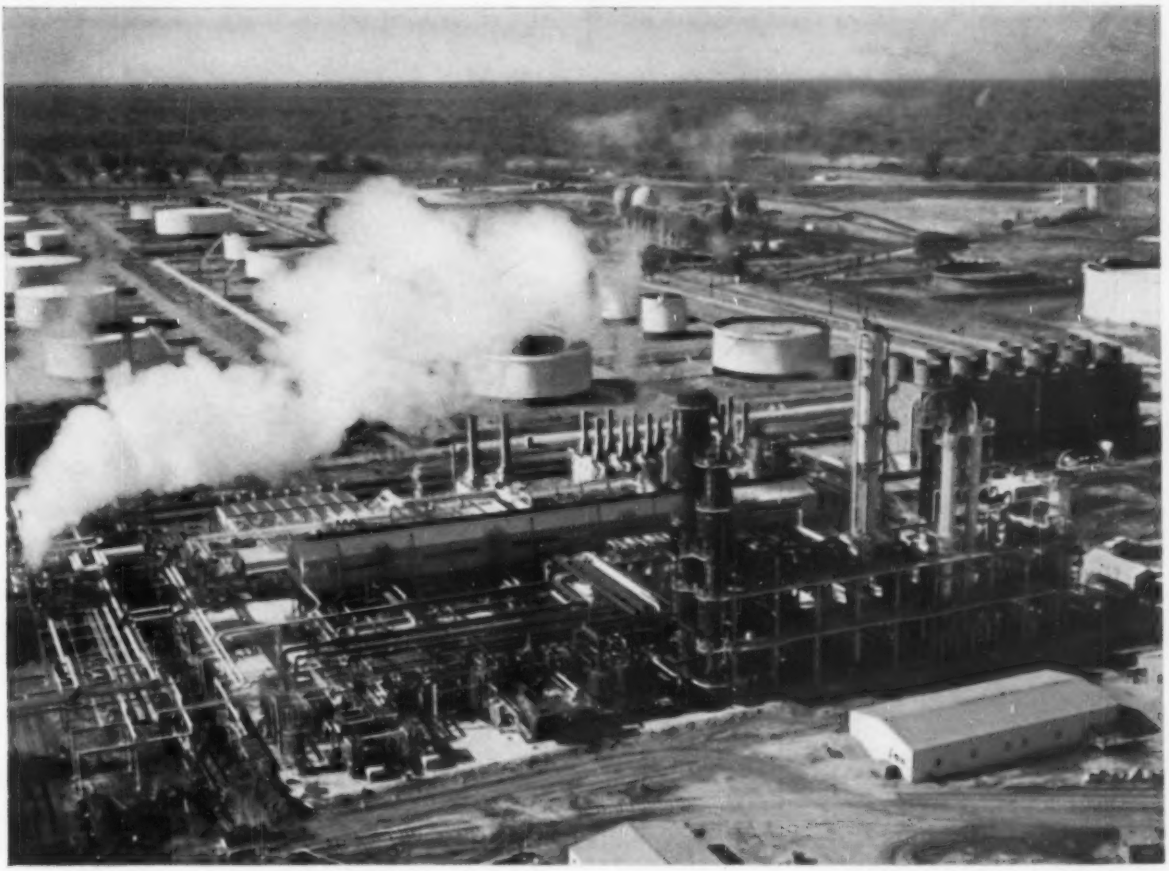
Cosden Petroleum Corp. has acquired Cities Service Oil Co.'s marketing properties in Dallas, Ft. Worth, Eastern New Mexico, and West Texas. The merger includes a credit-card exchange.

The Texas Co. is operating from new western headquarters following completion of new building in Los Angeles. **Structure houses 700 employes,** including refining, producing, and several other operation departments.

Russian instrumentation education will be discussed by a leading Soviet educator at the "Keynote Technical Session" of the **13th Annual Instrument-Automation Conference,** Sept. 15-19, Philadelphia. Session will also include timely review of military instrumentation.

Ashland Oil & Refining Co. has acquired the Ohio division of the Anderson-Prichard Oil Corp. Included in deal are solvent and chemical distribution plants in Cincinnati, Dayton, Cleveland, Akron, Columbus, Indianapolis, and Bellaire, Ohio.

Cities Service Oil Co., Inc., has launched a new dual product tank barge, built by Avondale Marine Ways, Inc. It is fitted with a double pipe and valve arrangement, enabling it to **carry ammonia and propane at the same time.** Barge is 238 x 47 x 13 feet, holds six 12 x 94-foot tanks with 10,000-barrel capacity.



Producing for today with a design for tomorrow

At Sweeny, Texas, one of the world's largest ethylene plants was recently completed for Phillips Chemical Company. It was designed and constructed by Stone & Webster Engineering Corporation.

With a current annual capacity of 180 million pounds of high purity ethylene, the plant design permits ready expansion of production to 290 million pounds per year. Flexibility provisions in the design allow the installation of the additional facilities required for this capacity increase without interrupting plant operations.

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All the comforts of home

A little bit of home flies with you when you take a trip on one of today's modern airliners. The friendly comforts . . . the small but important needs . . . are graciously and thoughtfully provided. No wonder so many people are flying.

Last year, America's airliners carried more than 42,000,000 passengers a total of 25 *billion* miles. Providing the fuels and lubricants to make this possible has been a big job for the petroleum industry. Texaco is proud of its part in this task—for during the last 23 years more scheduled revenue airline miles in the United States have been flown with Texaco Aircraft Engine Oil than with all other brands combined.

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PROGRESS AT YOUR SERVICE

THE TEXAS COMPANY

MEETINGS CALENDAR

1958 AUG. 18–21	American Institute of Chemical Engineers, Heat Transfer Meeting, Edgewater Beach Hotel, Evanston, Ill.
SEPT. 3– 5	American Petroleum Institute, Oil Information Committee Meeting, Hotel Statler, Boston.
3– 5	Cryogenic Engineering Conference, Massachusetts Institute of Technology, Cambridge, Mass.
4– 5	American Society of Mechanical Engineers, International Conference on Air Pollution, Hotel Statler, N.Y.
7–12	American Chemical Society, Fall Meeting, Chicago, Site Unreported.
10–12	National Petroleum Assn., 56th Annual Meeting, Traymore Hotel, Atlantic City, N.J.
14–19	Instrument Society of America, 13th Annual Instrument-Automation Conference and Exhibit, Philadelphia Convention Hall.
15–17	American Institute of Electrical Engineers, Conference on Petroleum, Baker Hotel, Dallas.
15–19	American Society of Mechanical Engineers, Process Industries Conference, Hotel Statler, Buffalo, N Y.
15–19	Instrument Society of America, Annual Instrument Automation Conference and Exhibit, Phil.
18	Natural Gasoline Assn. of America, Rocky Mountain Regional Meeting, Gladstone Hotel, Casper Wyoming.
21–24	American Society of Mechanical Engineers, Petroleum Mechanical Engineering Conference, Cosmopolitan Hotel, Denver.
22–24	Standards Engineers Society, 7th Annual Meeting, Benjamin Franklin Hotel, Philadelphia.
24–25	Western Petroleum Refiners Assn., Rocky Mountain Regional Technical-Industrial Relations Meeting.
28– Oct. 1	American Society of Mechanical Engineers' Power Conference, Hotel Statler, Boston.
OCT. 1– 2	Western Petroleum Refiners Assn. Third Annual Stream Pollution and Waste Disposal Conference, Lassen Hotel, Wichita.
6– 8	National Assn. of Corrosion Engineers, Northeast Regional Meeting, Boston.
9–10	American Society of Mechanical Engineers Fuels Meeting, Old Point Comfort Hotel, Old Point Comfort, Va.
13–15	National Electronics Conference, 14th Annual Forum on Electronic Research, Development, and Application, Hotel Sherman, Chicago.
13–15	American Gas Assn., Annual Convention, Atlantic City, N. J., Site Unreported.
15–17	Second Energy Resources Conference, "Energy and Its Impact on Society," Brown Palace Hotel, Denver.
19–21	National Assn. of Oil Equipment Jobbers, Annual Convention and Trade Show, Hotel Adolphus, Dallas.
20–24	National Assn. of Corrosion Engineers, Annual Conference and Exhibition of South Central Region, Roosevelt Hotel, New Orleans.
22–24	American Petroleum Institute, Meeting of Committee on Disposal of Refinery Wastes, Statler-Hilton Hotel, Dallas.
22–24	Society of Automotive Engineers, National Meeting, Lord Baltimore Hotel, Baltimore, Md.
23–24	Western Petroleum Refiners Assn., Session on Refinery Technology and Industrial Relations Meeting, Rufus Garrett Hotel, El Dorado, Ark.

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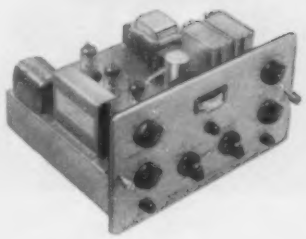

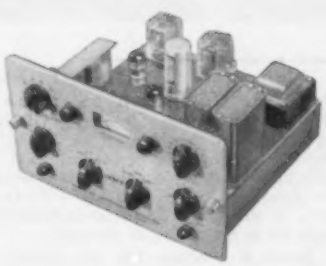

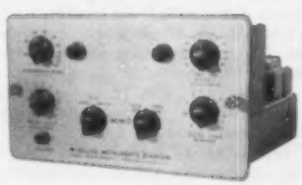

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MMP Position Type—Together with potentiometer can position a valve, valve positioner, or other positioning device . . . reset action adjustable from 0.6 to 100 repeats per minute . . . proportional band adjustable from 2 to 200% of controller range . . . rate action adjustable from 0 to 5.5 minutes.

MMD Duration Type—With potentiometer regulates input by adjusting on-time of a contactor on either electrical or fuel-fired installations . . . particularly adaptable when upsets are fast and recovery slow and when they are frequent and of large magnitude . . . keeps overshoot at startup or control point to minimum.

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*Also usable with Wheelco 2000 and 9000 Series.

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What's Happening . . .

. . . *Among Men* in the Industry

Esso Elects William Naden President of the Company

William Naden, a director and executive vice president of Esso Standard Oil Co., became president of the company August 1. He was elected on July 3 to succeed Stanley C. Hope, president since 1949, who plans to retire.

Naden joined Esso in 1927 as a chemist at the company's Everett, Mass., refinery. He became general superintendent there in 1934. Early in 1943, he was appointed general superintendent of Esso's Baltimore refinery. There, he accelerated construction of additional refining equipment to meet the wartime gasoline requirements.

He accepted a wartime government assignment in 1944 to serve as director of refining for District One of the Petroleum Administration for War. He coordinated oil industry refining activities and plant construction in the district, and accelerated production of all petroleum products needed for the war effort.

Upon completion of the government assignment, Naden returned to Esso as manager of employe relations, and was elected a director in 1946. In 1949, he became general manager of manufacturing for the company. He was elected a vice president in 1950 and became executive vice president in 1955.

William Naden

Kenneth A. Kaufmann has been appointed supervisor of plastics market research and development at Amoco Chemicals Corp. He joined Amoco from Spencer Chemical Co. where he was manager of plastics technical service and the sales service laboratory.

Kaufmann has a M.Ch.E. degree from Rensselaer Polytechnic Institute and a B.Ch.E. degree from Pratt Institute. He is active in the ASTM, Society of the Plastics Industry, and Society of Plastics Engineers.

The company also appointed **Dr. Frank G. Pearce** director of project engineering. He will supervise engineering development of new projects including raw material availability and process economics, and will be responsible for determining the technical soundness of projects before construction.

Prior to joining Amoco, Dr. Pearce spent 11 years with Pan American Petroleum Corp. in Tulsa, where he was supervisor of the Process Design section of the Research department. He has a B.S. degree from Rose Polytechnic Institute, and a D.S. degree from M.I.T.

Dr. Pearce is a member of the ACS and the AIChE.

John H. Udelhofen has joined the staff of the Whiting Research Laboratories, Standard Oil Co. (Ind.). He will conduct research on petroleum fuels. Dr. Udelhofen did his undergraduate work at St. Joseph's College, and has a Ph.D. degree in chemistry from Iowa State College. He is a member of the ACS.

James R. Colvert has also joined the Whiting staff. He has B.S. and M.S. degrees in mechanical engineering from Illinois Institute of Technology, and will be engaged in developing improved motor oils. He was formerly with Armour Research Foundation.

George W. Crafts, Jr., who obtained his B.S. degree in chemical engineering at M.I.T. will engage in pilot-plant studies of petroleum processes at Whiting. He is a member of the AIChE and was formerly with American Can Co.

Robert H. Smith, another new Whiting staff member has a B.S. degree in chemical engineering from Pennsylvania State University and a M.S. degree in chemical engineering from Cornell University. He will engage in economic evaluation of new refinery processes.

Robert C. Wiles of Tulsa has been named assistant controller and **Terence B. Redmond** of Chicago has been named manager of financial analysis and planning in the controller's department, American Oil Co. Both men will make their headquarters in the company's general offices in New York.

Wiles was formerly assistant comptroller of Service Pipe Line Co. in Tulsa. Redmond was supervisor of economic planning in the long-range planning department of Standard Oil Co. (Indiana) in Chicago.

William T. Tierney has been promoted to assistant superintendent of the Texaco Research Center at Beacon, N. Y. He was formerly an assistant supervisor of the Products Application department at the center, the company's largest research facility.

Dean C. McGahey has been named to succeed Tierney. Formerly a group leader in that department, he will be in charge of the Grease, Industrial Oils, and Fuels Testing groups.

John R. McLean, a mechanical engineer, will succeed McGahey.

Jack A. Horner has been named secretary of Shell Chemical Corp. He will retain his posts as vice president in charge of the Licensing division of Shell Development Co. and secretary of Shell Oil Co.

A graduate of Oklahoma University's law school, Horner joined Shell Oil in 1936 as a member of the legal department.

H. J. Maxwell assumed his duties as newly elected president of the California Natural Gasoline Association at its annual Board of Directors' Meeting held July 8, 1958. He is the assistant general manager producing department, Standard Oil Co. of Calif. Western Operations, Inc.

H. J. Maxwell

Maxwell first joined the C.N.G.A. in 1927, and has served as chairman of many committees and as a member of the Executive Committee.

K. C. Vaughan, manager of the natural gas and gasoline department of the Union Oil Co. of Calif., was presented as the newly elected vice-president. He will also serve as chairman of the Advisory Committee.

Dr. Robert N. Maddox has been named head of the Oklahoma State University School of chemical engineering. He has been acting head since May, 1957.

Maddox, 32, has been a member of the

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Men who work in slippery places . . . push heavy loads . . . or merely walk up and down stairs know what it means to have sure traction underfoot.

They can't wear shoes with cleats, but you can give them a floor with cleats—USS* Multigrip. Dozens of little studs provide maximum skid resistance in any direction. They are flat on top, easy to walk on—but do not catch the shoe.

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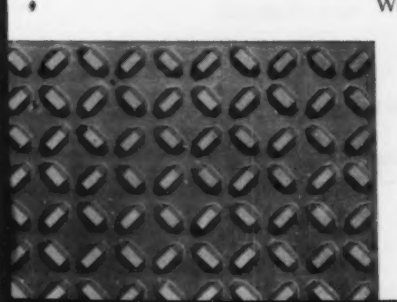

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DESIGNED FOR SUPERIOR PERFORMANCE

Full Bore Conduit: Full, round conduit through body and ball assures full flow through valve. No restriction, no turbulence, no more friction or pressure loss through the valve than through an equivalent length of pipe.

Leakproof two-way seal: The ball is suspended between Teflon seats under compression, assuring leakproof service at rated working pressures or vacuum, indefinitely. Actual seating surfaces are sealed away and protected from any abrasive action of the lading flow in either open or closed position.

Other advantages: Minimum parts, minimum maintenance. Quarter-turn opening and closing. Corrosion resistant. Recommended for temperatures to 250° F.

Available in carbon steel (ASA 150 lb., 300 lb.), and semi-steel (200 lb., 400 lb.); sizes range from ½" through 6".

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Liquid soaps, DDT and chlordane
Vinyl chloride
Butadiene liquid
Copper ammonium acetate
Carbon bisulphide
Cleaning naphtha
Lime and soda ash slurry
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Chlorinated solvents

W-K-M

OSU engineering faculty since 1950. He received his Ph.D. in chemical engineering there in 1955. He also holds degrees from Arkansas University and Oklahoma University.

Maddox has served as consultant for a number of Oklahoma industries, particularly in use of electronic computers to design petroleum handling facilities. He is also a consultant to the chemical engineering division of the Atomic Energy commission's Argonne National laboratory.

He is active in the National Society of Professional Engineers; Tau Beta Pi, National Engineering Society; and Sigma Xi, scientific research society. He is a registered professional engineer in Oklahoma.

Dr. Arthur E. Brooks will now direct all research on materials, for U. S. Rubber Co., while **T. J. Rhodes** will head up all engineering research and **Dr. D. Lorin Schoene** will direct liaison between the Research and Development department and the Manufacturing divisions.

Dr. Brooks has a Ph.D. degree in physical chemistry from the University of Chicago. He became a research chemist in the company's general laboratories in 1929, was appointed manager of the general laboratories in 1950, and was named manager of the company's new Research Center in Wayne, N. J., when it was opened last year.

Rhodes, an engineering graduate of Iowa State College, joined the company in 1942 as process engineer of a munitions plant it was operating in Des Moines, Iowa. Since 1953 he has been manager of the Mechanical Engineering Research department.

Dr. Schoene was formerly director of research and development for the rubber company's Naugatuck Chemical division. After obtaining a Ph.D. degree in chemistry from Iowa State College, he was appointed a research chemist in the company's general laboratories in 1939.

Albert W. Sublett has been appointed assistant supervisor for light oils planning in the Manufacturing department, Planning division of Standard Oil Co. (Indiana) at the company's general offices in Chicago. He has been with Standard since 1947 when he was employed as an inspection engineer at the Whiting, Ind., refinery. Most recently he has been assistant general foreman in the light oils division finishing department at the refinery.

W. D. Seyfried has been promoted to head Humble Oil & Refining Co.'s Research and Development division at Baytown, replacing **Dr. A. A. Draeger**, who has joined Humble's Marketing department in Houston.

Seyfried has been with Humble 20 years and assistant head of Research and Development division since 1948. He participated in the development of analytical techniques and in the organization of the laboratory groups for Baytown Ordnance works and for the butadiene plant, both operated during World War II by Humble for the government, and now owned and operated by Humble. Seyfried holds a B.S. degree in chemistry from Vanderbilt University.

Major General William M. Creasy, upon retirement as chief chemical officer of the U. S. Army on September 1, will join The Lummus Co. in New York as vice president, and will serve as director of the company's development center.

General Creasy received his B.S. degree from the U. S. Military Academy in 1926, and a M.S. degree in chemical engineering practice from M.I.T. in 1936. He also received training at the Chemical Warfare School, Command and General Staff College, Army-Navy Staff College and the National War College. He is a registered professional engineer in New York, Maryland and the District of Columbia, and is a member of the AICh.E, ACS, Washington Society of Chemical Engineers, Armed Forces Chemical Association, Association of the U. S. Army, and the Newcomen Society of America.

Men in the Industry . . .

Joseph R. Mares has resigned from the board of directors of Petro-Tex Chemical Corp. of Houston. He did this in order that he might undertake consulting work of a classified nature for the government, according to the company.

Mares, who maintains a consulting office in association with Henry Groppe at Houston, has been managing director of Petro-Tex since its formation in 1955. He will continue to be associated with the petrochemical activities of Petro-Tex in an advisory and consulting capacity.

Cutler

Jacbos

M. H. Cutler, chief structural engineer for Stone & Webster Engineering Corp. has been promoted to assistant engineering manager. Also promoted was *Robert M. Jacobs,* formerly Cutler's assistant. Jacobs is the firm's new chief structural engineer.

Cutler joined Stone & Webster in 1923 and has done design and consulting work on power stations and industrial and chemical plants in many parts of the U. S. and Canada. He graduated from Worcester Polytechnic Institute with a B.S. degree in civil engineering.

Jacobs joined the company in 1941 after working for the New England Power Co., the U. S. Forest Service, and U. S. National Park Service. He has worked on chemical plants, industrial plants, power stations and transmission lines, and nuclear facilities, including the Manhattan Project at Oak Ridge, Tenn., and the Synchrotron for the Brookhaven National Laboratories on Long Island. He graduated from M. I. T., with a degree in civil engineering.

Raymond F. Winch, chief of Sun Oil Co.'s Fuel Development section, Research and Development division has won a 1958 Sloan Fellowship for a year's executive development training at M.I.T. He began his studies recently as one of 36 men chosen throughout the Nation to participate in the M.I.T. program.

Dr. John R. Bates has resigned as technical adviser to the executive committee

For more data on advertised products, use Readers' Service Cards, last page.

Men in the Industry . . .

of the company's board of directors. Dr. Bates stated that he will reveal his plans for the future later.

Appointment of four section chiefs in Sun Oil Company's Research and Development division at Marcus Hook, Pa., has been announced.

The sections and their new managers are: Sales Service—**Wm. P. Dugan,** Petrochemicals—**Dr. Paul E. Oberdorfer,** Applied Research—**Dr. James L. Jezl,** and Catalytic Cracking—**Henry E. Reif.**

J. Fletcher Nelson has been named treasurer of Cities Service Oil Co., succeeding **H. J. McCusker,** who is retiring.

Nelson joined the New York headquarters staff in 1929 and has served in various executive capacities. He is an officer and director of several Cities Service subsidiaries.

Dr. Philip Lefrancois has been appointed research associate by The M. W. Kellogg Co. With Kellogg since 1944, he was formerly a research chemist.

Dr. Lefrancois holds a B.S. degree from the University of San Francisco, a M.S. degree from Loyola University of Chicago and a Ph.D. degree from Iowa State College, all in chemistry.

When Was Zinc Chromate First Used in Corrosion Inhibitors?

Over 10 years ago, in 1947, Wright introduced the use of zinc, for corrosion control, in a new Wright product called Penechrome Z. Since then other Wright Penechromes, containing zinc chromate and organic additives, have proved in years of field service the greater effectiveness of zinc-containing corrosion inhibitors. Wright research, as always, will continue developing new approaches to the solution of your water side corrosion problems.

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- Nelson Chemical Proportioning Pumps

Edward J. Brenner has been appointed acting assistant director in the Technical Information division of Esso Research and Engineering Co. He had been a contract attorney in the firm's process licensing unit. Brenner's new position is a rotational assignment. He's filling the post left vacant by **Gordon W. Duncan** who is currently on a special 12-month assignment in New York as assistant general secretary of the Fifth World Petroleum Congress, scheduled to be held next June.

Brenner joined Esso in 1950 and moved to the process licensing unit two years ago.

Lewis A. Winkler and **Leo V. Mullen, Jr.,** have been given new assignments in the company. Winkler has been named head of the company's chemicals liaison unit headquartered in London. Mullen, formerly a group head in the additives section of the firm's technical service unit, is now a section head in charge of additives activities.

Dr. George P. Baumann and **George Claypole** have been named engineering associates. Claypole, in England since January on an assignment, has traveled extensively since he joined the company nearly 12 years ago. His work has involved engineering development, design of refinery equipment, start-up, and "trouble-shooting" jobs for refinery projects of affiliates of Standard Oil Co. (New Jersey).

Dr. Baumann, who recently returned from a two-month assignment in Japan, joined Esso Engineering in 1945. His engineering work has included process engineering, and design of new equipment, refinery planning, and engineering research.

Dr. Roy A. Westlund, Jr., has been appointed a section head in Esso's Chemicals Research division, and **Dr. John F. Ryan** has been named a section head in the Chemicals Development division.

Dr. Westlund will be in charge of a section dealing with applications development of polymers and chemicals. Dr. Ryan had been an acting section head since last October when he returned to Esso Research from a ten-month rotational assignment with Esso Standard Oil Co. in New York.

Erving Arundale will move from his post of assistant director in the Technical Service unit to become assistant director in the firm's Chemicals Research division. He will take charge of a new program involving production application development in polymers and chemicals.

Robert F. Leary will leave his post as assistant director in the Chemicals Research division for an assistant director's position in the Technical Service unit.

Arundale began his Esso career in 1937 as a student engineer at the Bayway Refinery of Esso Standard Oil Co. Leary began his Esso Research career in 1942. His research work has focused on steam cracking and a wide variety of other processes including butyl rubber.

Three Esso Research and Engineering patent attorneys have been awarded the title of patent associates, and two of the firm's scientists have been named research associates. **Charles D. Stores** who heads Esso Research's patent office in Washington, D. C., **Peter H. Smolka,** and **Seymour Stahl** are patent associates.

Named research associates are **Albert M. Gessler** and **Erik Tornqvist.** Both men are members of the Chemicals Research division.

Walter W. Gleason and **Robert F. Neu** have been named section heads. Gleason, who recently returned from a year's as-

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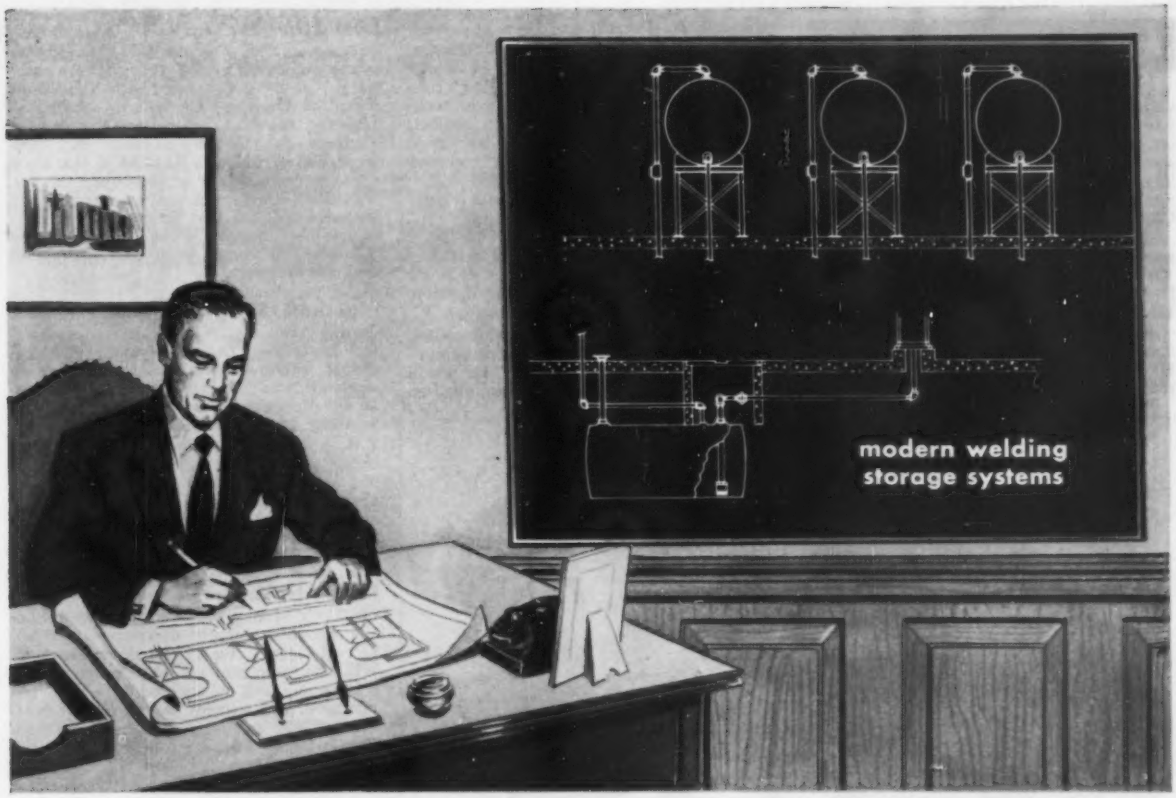
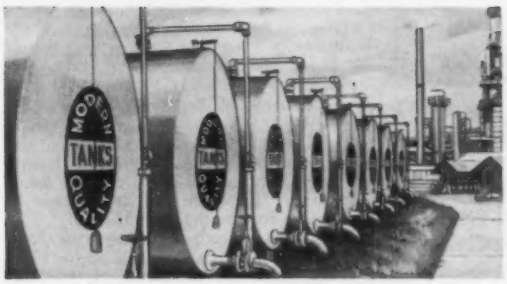


efficient storage is our business



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Men in the Industry . . .

signment in England with the affiliated Esso Research, Ltd., Abingdon laboratories, has been appointed head of a polymers section in the Technical Service unit. Neu is in charge of a section concerned with applications development work in the Chemicals Research division.

Five additional men have been named research associates. They are **Herbert H. Vickers, Oliver G. Lewis, William G. Dukek, Jr., Charles W. Foust,** and **Dr. Horace W. Gerarde.**

Four recently named engineering associates are **Moss F. Sheely, Earl M. Hawkins, Christopher E. Loeser,** and **Arthur K. Scott.**

Wayne A. Proell has been appointed division director in the Standard Oil Co. (Indiana) Research department in charge of work on solid propellants used in missiles and jet aircraft. He took over technical direction of the propellant projects when he was named section leader in 1955. In his new position he will continue to direct solid propellant research activities at both Whiting and Seymour laboratories.

Peter J. Cambourelis has been named technical assistant to the director of product development, Solvay Process division, Allied Chemical Corp.

A graduate of M.I.T., he holds a B.S. degree in business and engineering administration. Before joining Solvay, he was a sales engineer for Rem-Cru Titanium, Inc.

Burt Stout has been added to the engineering staff of Tuloma Builders, a Tulsa based engineering and construction company. He was formerly with the Fluor Corp. at Houston. He will be located at Calgary, Alberta, and will serve as project engineer for the engineering and construction of Hudson's Bay Oil & Gas Co.'s gas processing plant at Cessford, Alberta. The contract for this project was recently awarded to Canadian Comstock Co., Ltd., in association with Tuloma Builders, an affiliation developed to serve Canada's oil and gas industry.

Marshall Sittig has joined W. Alec Jordan Associates, New York firm of chemical marketing consultants and technical public relations specialists, as vice president. He was formerly president and managing director of the American Lithium Institute Inc., Princeton, N. J.

A graduate of Purdue University in chemical engineering, Sittig is the author of more than 40 technical articles on chemical engineering, petroleum refining, and metallurgical developments, some of which have appeared in PETROLEUM REFINER.

Frank H. Barnes, Standard-Vacuum Oil Co.'s manager of Lubricating & Special Products Supply department, retired recently after 41 years of service. **Frank V. Williams,** who was assistant manager, has been appointed to succeed him. He had managed procurement of Stanvac lubricating oil and special products since 1943. Barnes began his career in 1917 with the former Anglo-American Oil Company, Ltd., a Jersey Standard affiliate.

Frank L. Dennis, a Washington newspaperman and lawyer, has been appointed to the executive staff of the American Petroleum Institute. He will be located in the Institute's Washington office, having resigned as director of the Press and Publication Service of the U. S. Information Service.

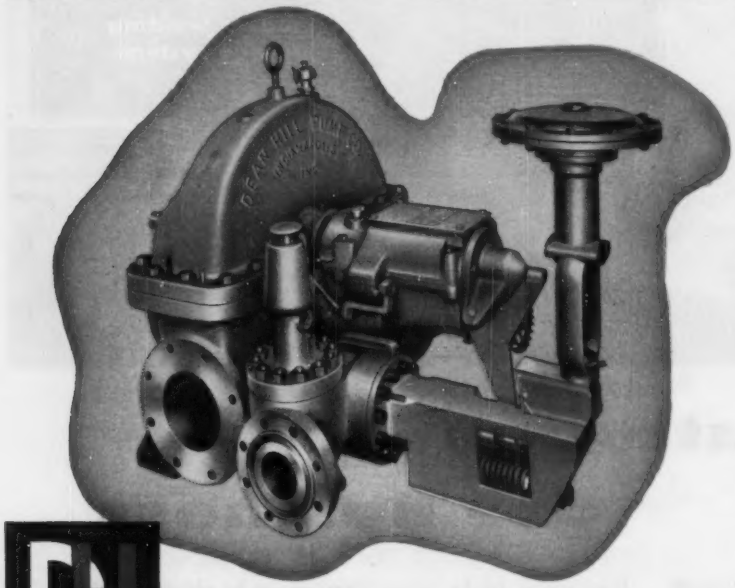
Dennis, a graduate of the University of Oklahoma and Harvard Law School, has been an executive editor of the Daily Oklahoman, the Boston Herald, and the Washington Post, and he is a member of the District of Columbia Bar.

J. P. Jones of Bradford, Pa., was re-elected president of the Pennsylvania Grade Crude Oil Association at a meeting of the Association board of directors following the annual Penn Grade meeting in Bradford. Jones will continue as director of production for the association.

Re-elected at the June 20 meeting were: **George J. Hanks,** president of South Penn Oil Co., first vice president; **A. C. Simmons,** Simmons Oil Co., second vice president; **Fayette B. Dow,** Washington, D. C., vice president and general counsel; **Samuel Messer,** Quaker State Oil Refining Corp., treasurer; **C. L. Suhr,** South Penn Oil Co., **C. G. Johnson,** Quaker State Oil Refining Corp., and **Glenn E. Scott,** Wolf's Head Oil Refining Co., assistant treasurers.

Dr. Marvin J. Den Herder has been appointed a section leader at the Whiting Research Laboratories of Standard Oil Company (Indiana). He was most recently a group leader in research on hydrocarbon reactions. He will now be in charge of fundamental and exploratory research aimed at the discovery of new reactions and improvement of refinery process.

Also announced was the appointment of **Dr. Keith W. McHenry, Jr.,** as a group



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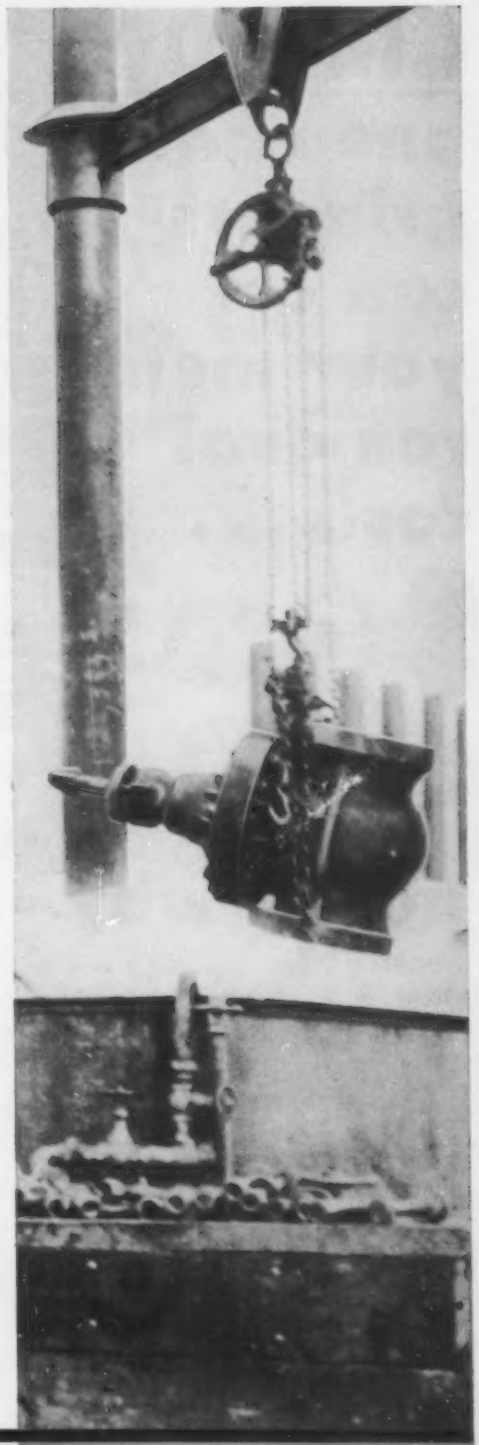

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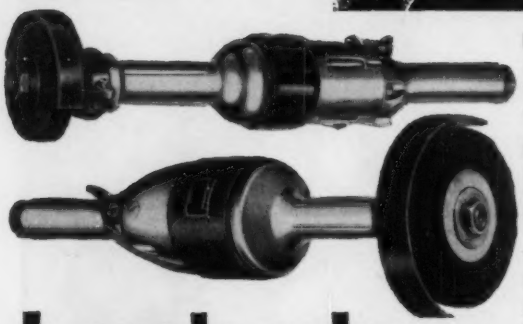

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Men in the Industry . . .

leader at Whiting. He joined Standard in 1955, and has most recently been doing fundamental research on catalytic cracking. He will now be in charge of work on the development and improvement of catalysts.

Garbis H. Meguerian has been named a group leader at Whiting. After joining Standard in 1952, he did research on the treatment of petroleum fuels. More recently, he has been doing research on the combustion of hydrocarbons. He will now be in charge of research on combustion problems, including engine knock.

John C. Anderson has been named controller for Vickers Petroleum Co., Inc. He will take charge of Vickers' newly formed Controller division and supervise the Accounting, Traffic and Purchasing departments.

Anderson was formerly controller for Pontiac Refining Corp., assistant controller of Burlington Industries, a management consultant with Price Waterhouse & Co., an assistant chief specialist with Arabian American Oil Co., a tax consultant with Barnett & Co., and territory accountant with Standard Vacuum Oil Co.

John B. Duckworth has become research coordinator in the Standard Oil Co. (Indiana) Research department at Chicago. He will be responsible for liaison between the company's Research department and major automotive manufacturers and government agencies concerned with trends in petroleum-product quality. At present he is division director of automotive research at the company's Whiting, Ind., research laboratories.

James Harrop and **H. H. Meier** are new assistant managers of Humble Oil & Refining Co.'s Baytown refinery. Harrop is responsible for the Coordination and Blending, Technical, Employee Relations, Medical, Accounting and Plant Protection divisions. The Operating, Utilities and Oil Movements, and Mechanical and Construction divisions are under Meier.

H. F. Goss has been named operations advisor to Harrop and will work on special assignments.

W. B. Franklin heads the new Technical division, while **H. F. Hartman** is now mechanical and construction superintendent.

Wayne H. Walker is the new administrative manager for Pan American International Oil Co. in New York. He will also be a director of the company.

Walker has moved to New York from Tulsa, where he has served Pan American Petroleum Corp. as procedure supervisor since 1952. He will have general supervision over staff activities, including purchasing, industrial and public relations, accounting, and other related areas.

C. Willis Stose has been appointed manager of Atlantic Refining Co.'s Philadelphia refinery. He succeeds **D. T. Shaw**, manager of the refinery since 1952, who is retiring.

A graduate of M.I.T., Stose joined Atlantic's Research and Development department in 1925. He has been superintendent of the Philadelphia plant since 1957.

Harry F. Huf has become general man-

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Here's a new line of vertical centrifugal pumps easily tailored to your exact needs.

For process transfer or heavy-duty sump service, these pumps have features which assure long trouble free life with a minimum of maintenance.

Because they're built from standard parts, delivery is fast and there is no premium charge for custom building. When you want to change pit depth or pump ratings, you merely replace necessary parts. Units may be adapted in the field. Shafts and pipe columns are available for any pump length from 2 to 20 ft. in 6-inch increments.

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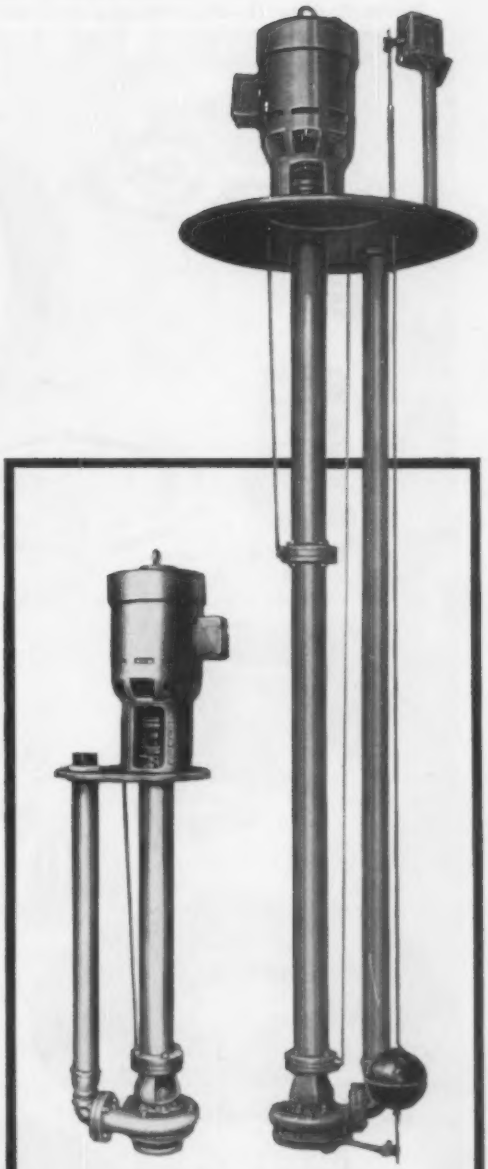

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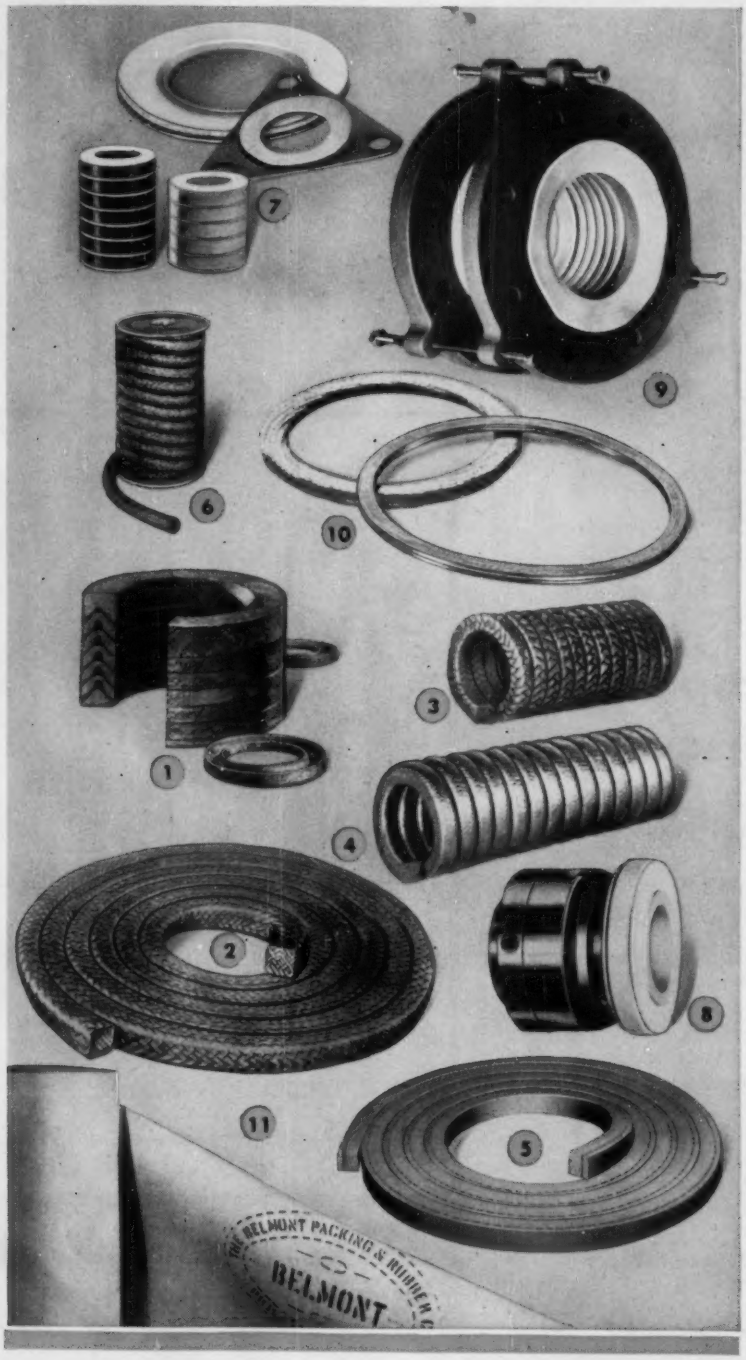

Men in the Industry . . .

ager of the company's Engineering and Construction department. He has been a member of the department since 1935 and for the last four years has served as administrative manager. He succeeds **Dr. L. M. Goldsmith,** who is retiring.

Robert D. Bent is now manager of the newly created Technical Service department. He was formerly assistant director of the development division of Atlantic's Research department.

A graduate of the University of Pennsylvania, Bent joined Atlantic in 1935 as a process operator in the Research and Development department. He had served as assistant director of the development division of that department since 1953.

Frank S. Sawyer has been appointed manager of construction for J. F. Pritchard and Co. A graduate of the University of Maine, he has almost 40 years of experience in the construction industry.

Retiring after nineteen years with the company, **W. H. MacKay** has been succeeded by **R. H. Bradley** as district manager of Pritchard's Houston Office.

Paul L. Work has been promoted to acting group leader at Tidewater Oil Co.'s Delaware refinery. Formerly at spectroscopist, he joined Tidewater last year.

Colin E. Spearing has been elected to the board of directors of Kellogg International Corp. He was formerly general manager of the Refineries department of British Petroleum Co., and a director of the B. P. Trading Co. British Petroleum's post war refinery expansion programs in Great Britain, Europe, Middle East and Australia were supervised by Spearing, who is a vice president of the Institute of Chemical Engineers in Great Britain.

T. J. Hull is the new executive secretary, National Association of Corrosion Engineers. **R. W. Huff, Jr.,** became assistant executive secretary. Hull had been assistant executive secretary for the year preceding.

Hull joined NACE in February, 1952. He was in charge of central office work with regions and sections for two years and then became technical secretary, a position involving the association's technical committees. He attended the U. S. Naval Academy and holds a B.S. degree in mechanical engineering from the University of Houston.

Huff has handled various administrative details of the association's activities, particularly in conection with annual conferences and exhibits held by NACE, and with NACE membership activities in regions and sections. He has a B.S. degree in chemical engineering from Texas A & M.

Leland A. Smith has been appointed a vice president of Caltex Service Co., a division of California Texas Oil Co., Ltd. He will handle marine matters for the Caltex fleets. Smith joined Standard Oil Co. of California in 1924 and in 1940 became the company's Eastern Seaboard marine representative. During World War II, he served with the War Shipping Ad-

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ministration where he was appointed assistant director. In 1946 he joined Overseas Tankship Corp., a Caltex affiliate, went to London in 1950 as general manager, Overseas Tankship (U.K.) Ltd., and returned to New York in 1952 as general manager, marine division, California Texas Oil Co. Ltd., his last position.

Thomas L. Wark has been appointed special assistant to the president of Tidewater Oil Co. Formerly western division general manager, he will continue to make his headquarters in San Francisco.

Vice President **Charles R. Brown** has been named Western division general manager in San Francisco, succeeding Wark. Brown was formerly central division general manager in Tulsa.

Lloyd Armstrong, previously Southern division assistant general manager, with Houston headquarters, has been appointed central division general manager, succeeding Brown at Tulsa.

—Deaths—

L. A. Mekler, 63, a chemical engineering consultant specializing in petroleum chemistry, died in New York City, June 15. He was with Universal Oil Products more than 20 years, and had been a consultant since 1948. Mekler was the author of more than 35 technical articles, many of which appeared in PETROLEUM REFINER.

Bryant Franklin Kenney, 49, a director of Standard-Vacuum Oil Co., died July 14 in New York of a kidney ailment after an illness of several months.

Kenney graduated from M.I.T. in 1930 with a B.S. degree in mechanical engineering, and began his oil industry career in 1930 at Esso's Bayway (N. J.) refinery.

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Selma Foundry & Machine Co., Selma, Ala.
Allen & Jemison Hdwe. Co., Tuscaloosa, Ala.
J. G. Christopher Co. of Cocoa, Cocoa, Fla.
J. G. Christopher Co., Jacksonville, Fla.
Harry P. Leu, Inc., Orlando, Fla.
Gulf Coast Ind. Sup. Co., St. Petersburg, Fla.
Van Brunt & Yon, Inc., Tallahassee, Fla.
Knight & Wall Co., Tampa, Fla.
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J. M. Tull Metal & Sup. Co., Atlanta, Ga.
Morgans, Inc., Savannah, Ga.
Whitehead Hardware Co., Valdosta, Ga.
Georgia Alabama Supply Co., West Point, Ga.
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Taylor Iron Works & Supply Co., Macon, Ga.
Columbia Supply Co., Columbia, S.C.
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Keith-Simmons Co., Nashville, Tenn.
Mill & Industrial Sup., Inc., Louisville, Ky.
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Ferebee-Johnson Co., Lower Basin, Va.
Graves-Hymphreys Hardware Co., Roanoke, Va.
Taylor Supply Co., Norfolk, Va.
Parker-Nimmo Supply Co., Salem, Va.
Superior-Sterling Co., Bluefield, W. Va.
McJunkin Corp., Charleston, W. Va.
Walter B. Gallagher Co., Philadelphia, Pa.
H. N. Crowder Co., Easton, Pa.
Speck Marshall Co., McKees Rocks, Pa.
E. S. Atkinson Co., Erie, Pa.
The M. F. Murdock Co., Akron, O.
John J. Disch Co., Cleveland, O.
McJunkin Corp., Columbus and Marietta, O.
The Sterling Rubber Products Co., Dayton, O.
Industrial Supply Co., Terre Haute, Ind.
Housh Industrial Supply Co., Evansville, Ind.
Indianapolis Belting & Sup. Co., Indianapolis
Idaho Industrial Supply Co., Boise, Ida.
Mechanical Rubber & Supply Co., Peoria, Ill.
Amstan Supply div. of American Radiator & Sanitary Corp., Rock Island, Ill.
Barrett-Christie Co., Chicago, Ill.
Plumb Supply Co., Des Moines, Ia.
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Union Supply Co., Denver, Colo.
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Joplin Supply Co., Joplin, Mo.
The Foster & Felter Co., Kansas City, Mo.
Mineral Products Co., St. Louis, Mo.
Rubber Products Co., St. Louis, Mo.
John Day Rubber & Supply Co., Omaha, Neb.
Empire Ind. Serv. Sup. Inc., Green Bay, Wis.
N. L. Kuehn Co., Milwaukee, Wis.
Champion, Inc., Iron Mountain, Mich.
A. J. Baxter & Co., Detroit, Mich.
William S. Roe, Inc., Harrison, N.J.
Gerweck & Auerbacher, Inc., Irvington, N.J.
Allied Rubber Co., Newark, N.J.
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Claxton Asbestos Co., Buffalo, N.Y.
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P & H Supply Co., Muskogee, Okla.
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Briggs-Weaver Machinery Co., Dallas, Tex.
Asarco Mercantile Co., El Paso, Tex.
Tri-State Industrial Sup. Co., El Paso, Tex.
Southwestern Rubber & Packing Co., Houston, Tex.
The W. H. Steigerwald Co. Inc., Houston, Tex.
Lufkin Supply Co., Lufkin, Tex.
Robert Swaim Co., Paris, Tex.
San Antonio Mach. & Sup. Co., San Ant., Tex.
Wichita Supply Co., Wichita Falls, Tex.
Frank Graves Co., South Seattle, Wash.
Manning Packing & Supply Co., Portland, Ore.
Warren & Bailey Co., Los Angeles, Cal.

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Butler & Sepviva Streets, Phila. 37, Pa.

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Reviewing New Books . . .

Advances in Refining

"Advances in Petroleum Chemistry and Refining," Volume I, edited by K. A. Kobe and J. J. McKetta, Jr., is the first of a series of books designed to summarize and evaluate recent developments in petroleum refining and petrochemicals. Each volume will cover topics falling into five major classifications, as follows:

- Economic and Future Trends
- Unit Operations and Design
- Refining Processes
- Petrochemicals
- Mechanical Equipment

Each topic in this first volume has been carefully treated by authors who are experts on their subject matter. They have provided references to the original literature sources on which they have drawn, and the unified treatment they are able to give their topics greatly facilitates the reader's understanding and retention of the information presented.

This book should appeal and be valuable to everyone interested in refining and petrochemical technology. It will be particularly appreciated by those who wish to catch up on fields outside their major interest.

Because this is the first book in a series, it has sometimes been necessary to provide rather basic information which the experienced reader will already have at his command. However, this well-conceived, well-edited and beautifully put-together book represents a very worthwhile contribution in the struggle to keep the petroleum technologist afloat on the floodtide of present-day technical information. Future volumes have a very high standard to uphold.—Reviewed by Richard Fleming.

(McKetta, J. J., and Kobe, K. A., *Advances in Petroleum Chemistry and Refining,* Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 641 pages, $13.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

Record of Investments

"Chemical and Petroleum Investment Record" is an historical record of 69 companies in the chemical, petroleum and related industries. The book's graphs and tables answer such questions as:

- Which companies within the industry have yielded the highest rate of return on $1,000 invested between any year since 1935 and Dec. 31, 1957?
- How important has it been to time an initial investment in any company as evidenced by comparative dollar return on an investment made in any year between 1935 and 1956?
- What has been the relative importance of capital appreciation and dividends in return on investment since 1935?

This record will be of interest to investment analysts, registered representatives, chemical and petroleum executives, individual investors, and persons with an interest in the chemical and petroleum industries.

Because the record is historical, it cannot be interpreted as a recommendation of any particular investment decision.

(Staff, Chemical Economics Handbook, *Chemical and Petroleum Investment Record,* Stanford Research Institute, Menlo Park, Calif., 142 pages, $10.00).

Applied Mathematics

"Applied Mathematics for Engineers and Physicists" is designed for the general advanced mathematics course offered to applied scientists. It covers a wide range of topics in the advanced calculus fields, and gives the engineer and applied physicist the principal mathematical techniques he needs to analyze the usual mathematical problems that arise in practice and to understand important current technical papers.

The text covers subjects essential to the understanding of present-day engineering analysis: infinite series, complex numbers and the complex variable, Fourier analysis, the Laplace transform theory, vector and tensor analysis, partial differential equations, modern algebraic methods including matrices, integral equations, the calculus of variations, and ordinary nonlinear differential equations.

(Pipes, Louis A., *Applied Mathematics for Engineers and Physicists,* McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y., 723 pages, $8.75. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

Organic Synthesis

"Unit Processes in Organic Synthesis" is virtually a complete rewriting of a successful book. It is intended for readers having a sound training in physics, physical chemistry, and mathematics.

In the discussion of each unit process, there is first a survey of the field; then the chemical, thermodynamic, kinetic, and engineering factors are discussed. This is followed by a description of equipments and materials of construction; finally, examples of industrial applications are presented.

(Groggins, P. H., *Unit Processes in Organic Synthesis,* Chemical Engineering Series, McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y., 1069 pages, $17.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

Process Economics Text

Methods developed from experience all too often must be re-evaluated in the light of changing economic conidtions if optimum plant designs are to result. "Chemical Process Economics" provides a consistent and reasonably concise method for the solution of these problems involving economic alternatives.

Problems involving selection of new equipment, design of process plant components, and operation of existing plants are all handled by means of the same basic relationships.

A special feature of the book is the appendix devoted to "rules of thumb" for the practical design of chemical plants, based on the experience of many engineering firms. This enables the reader to arrive at reasonable answers quickly when there is is insufficient information to justify detailed consideration.

(John Happel, *Chemical Process Economics,* John Wiley & Son, Inc., 440 Fourth Ave., N. Y. 16, N. Y., 1958, 291 pages, $8.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U. S. A.)

Steam Turbine Standard

Tentative Standard 615, API Specification for Mechanical Drive Steam Turbines for General Refinery Service, can be obtained from the American Petroleum Institute. This is the First Edition, April, 1958.

This specification gives the minimum requirements for general-purpose and special - purpose horizontal, vertical, condensing, or non-condensing mechanical drive steam turbines used in general refinery services, where maxium initial steam conditions do not exceed 850 psig or 750 F and speeds do not exceed 12,000 rpm. Design, materials, inspection and tests, preparation, shipment, erection, drawings and other required data and proposals are covered.

(Tentative Standard 615, *API Specification for Mechanical Drive Steam Turbines for General Refinery Service,* Publication Dept., American Petroleum Institute, 50 W. 50th St., N. Y. 20, N. Y., 28 pages, $1.50).

Unfired Pressure Vessels

Chapter VI (Unfired Pressure Vessels) of the API Guide for Inspection of Refinery Equipment is now available. This is the first edition, 1958.

The guide covers common methods and materials of construction; construction standards and inspection in service; reasons for inspection; causes of deterioration (corrosion, erosion, metallurgical changes, mechanical forces, and faulty material of fabrication); frequency and time of inspection; and methods, tools, and limits of inspection.

(Chapter VI, API *Guide for Inspection of Refinery Equipment,* Publication Dept., American Petroleum Institute, 50 W. 50th St., N. Y. 20, N. Y., 47 pages, $2.00.)

Liquid Viscosity Studies

This report from the Office of Technical Services was compiled as a preliminary step toward the development of theories of liquid viscosity. It reviews critically the more important approaches to the viscosity problem in the published literature. Consideration of some the leading studies led the authors to conclude that no fully satisfactory theory of viscosity has yet appeared in the literature.

F. C. Collins, *Theoretical and Experimental Studies of Liquid Viscosity,* PB 131407, Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C., $1.50).

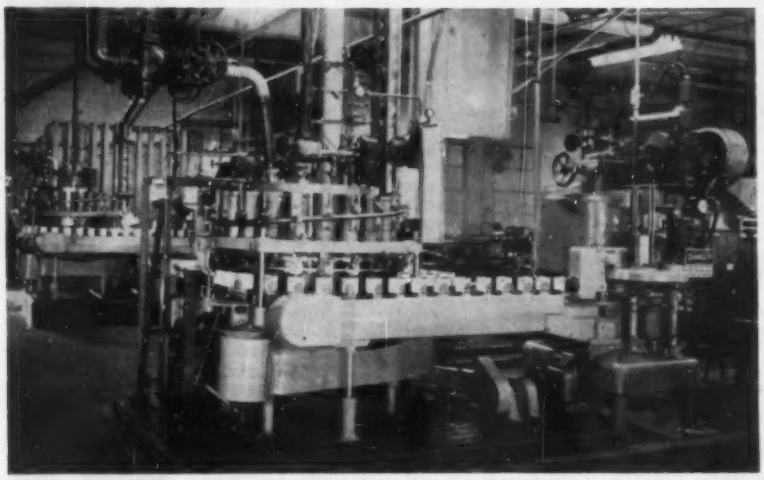
Competition in Oil

"Competition in Oil" embraces not only the world's largest concentration of refining capacity along the Louisiana and Texas Gulf Coasts, but also the great refining and consuming centers of the Atlantic seaboard.

This book defines the Gulf Coast refinery market and certain of its structural features: the nature of demand for refinery products, the collection and dissemination of information on prices, the types of buyers and sellers, the degree of concentration and the conditions of entry. It then supplements this analysis with a discussion of market performance: the behavior of prices, the efficiency of existing plants, the adequacy of over-all capacity, the level of profits, and the extent and character of innovation.

(Hamilton, Daniel C., *Competition in Oil,* Harvard University Press, Cambridge, Mass., 233 pages, $6.75. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

PFAUDLER
CORROSIONEERING NEWS



425 quarts a minute filled on this Pfaudler 21-station lube filler at Texaco plant. A total of three Pfaudler fillers handle all lube packaging requirements of the Port Arthur plant.

Filling without spilling at Texaco to 99.9969% accuracy

Texaco uses just three machines at its Port Arthur plant to fill a complete line of motor oils, hydromatic fluids, and antifreeze in quarts and gallons.

Two of these machines — RPL-21 type Pfaudler piston fillers—fill 410 to 425 quarts a minute. They each hold another 65 quarts a minute in reserve capacity. They fill at any viscosity over the complete temperature range 80° to 105° F.

The third machine — an RPL-7 Pfaudler filler — handles gallons at 60 to 80 per minute.

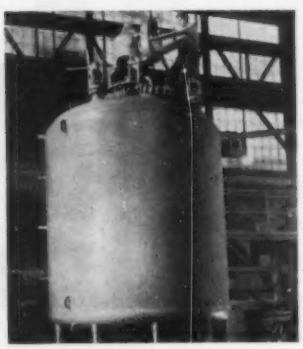
All three machines are accurate to ±0.1 ounce by liquid volume. They eliminate spillage completely . . . send cans from the plant with labels and cartons *clean*. No maintenance is required beyond routine cleaning.

There are only three primary wearing parts on these Pfaudler fillers: piston and valve rollers and valve trip cams. All are inexpensive and easy to replace. There are no connecting rods or wrist pins to cause trouble.

Simple, positive adjustments of the can support rails eliminate product spillage by compensating for the centrifugal forces generated during high-speed filling. An accelerating infeed screw pushes cans in uniformly without jamming.

Cleaning is easy, too. You empty the bowl through a drain port, flush with kerosene, put the machine through a few revolutions, and it's clean.

There's more information about the complete line of Pfaudler fillers offered in the coupon.



This is the most glassed-steel agitated reactor you've ever seen in one piece. O.D.: 120 inches. Height: 125 inches. Capacity: 7000 gallons. Material: glassed steel. It will be used to process monochloroacetic acid and alcohol at 158° F. The jacket is designed to take a 25 psi pressure at 350° F. This vessel uses a conventional three-blade impeller *without a foot bearing*. The agitator is set only 10 inches off bottom. *Moral:* We are ready to answer the most unusual process requirements and to glass any vessel from one-gallon lab units to giants like this. *For the record:* We've made vessels up to 35,000 gallon capacity for large volume storage and these are glassed, too!

New flush valve boasts one-piece glassed head and stem

When we took all the porcelain out of this bottom outlet flush valve, we eliminated a major cause of valve failure.

Head and stem are *one piece and glassed*. No cement. The seat is made of rigidized Teflon-glass fiber and its bevel mates with that of the spherical head. Rubbing the glassed head on the Teflon seat produces absolutely no static. The Teflon also has some "give" so you can get a firm seating without danger of cracking the head covering, a continual problem with the old porcelain designs.

We don't have to tell you of the positive and leakproof sealing you get with this ball-joint construction. And it's probably equally self-evident that the rounded, glassed head eliminates product build-up during processing.

So all there is left to tell is that the new design is interchangeable with existing valves you might now be using and that the unit costs no more than a conventional stainless steel valve. Sizes range from 1½ by 1 to 8 by 6 in six different models.

Anything else you might want to know is covered in Data Sheet 42 which is offered in the coupon.

PETROLEUM EQUIPMENT by PFAUDLER

THE PFAUDLER CO.
a division of
PFAUDLER PERMUTIT INC.
Dept. PR-88, Rochester 3, N.Y.

Please send information on ☐ Bltn. 878 RPL Oil Fillers; ☐ DS-42 Flush Outlet Valve; ☐ Bltn. 947 Buyer's Guide.

Name.....

Title.....

Company.....

Address.....

City..... Zone..... State.....

For more data on advertised products, use Readers' Service Cards, last page.

What Suppliers Are Doing . . .

McDonald

R. C. McDonald has been appointed New York district manager of Clark Brothers Co., succeeding **Robert J. Spears,** recently appointed assistant general sales manager and transferred to the Olean home office. Since his graduation from Northeastern University in 1939, with a B.S. degree in chemical engineering, McDonald has served as application and sales engineer for three manufacturers in the field. In 1946 he joined Pacific Pumps, Inc., and in 1949 he was transferred to Clark Bros. Co. as senior sales engineer in the New York district office. In 1953, he was placed in charge of the Philadelphia district office.

McDonald will now supervise Clark sales activities in the New York, Pennsylvania and Washington, D. C., territories.

Sewell

J. B. Sewell has been appointed president of The Garlock Packing Co. of Canada, Ltd.

Also named vice president of marketing of the U. S. firm this year, he joined Garlock in 1935 as a Canadian sales representative. In 1947 he was promoted to vice president of the Canadian operations. In 1954 he was transferred to Palmyra, N. Y., to assume duties as Garlock's general sales manager, a position he held until 1955 when he was designated vice president of sales.

Walker

Vernon S. Walker has been appointed a steel valve sales representative for Kerotest Manufacturing Co. For the past 12 years he has been actively associated with the petroleum industry, supplying companies in both the U. S. and South America with valves and related equipment for refining operations. He studied mechanical engineering at both the University of Oklahoma and Arizona State College.

Territories assigned to Walker include Oklahoma and Kansas, and a portion of Missouri. His office and residence is in Tulsa.

Bremer

Dr. Clarence Bremer, formerly director of research, has been appointed technical director of Oakite Products, Inc. He will be responsible for the company's research and product development, and technical service laboratories.

A member of the company's board of directors since 1956, Dr. Bremer has been with Oakite since 1942. He is a member of the ACS, the American Ordnance Association, the American Society for Metals, the NACE, Institute of Chemists, and Sigma Xi, the national scientific honorary society.

Woodfield

Alan J. Woodfield has been named executive vice president of Sealol Corp., Providence, R. I. He was formerly executive vice president and general manager of LaFavorite Rubber Co., and before that a vice president of Continental Paper Co. Woodfield joined Sealol last fall as controller and will continue in that capacity.

Other changes include naming **Justus B. Stevens** vice president of the Seals and Accessories group; **Frank Bottomly,** vice president of the Tools and Equipment group; **W. F. Holt,** director of personnel; and **J. T. Colwell, Jr.,** manager of the Accounting and Cost department.

J. P. Gasser has been named executive vice president of Dresser Industries, Inc., Dallas. He has long been associated with the Seaboard Oil Co., of which he was executive vice president and member of the executive committee, 1953-1958. After being elected vice president of Seaboard in 1950, he was made a member of the board of directors from 1951 through 1958, when he became executive vice president.

Gasser will direct the activities of Lane-Wells, Ideco, Inc., Magnet Cove Barium, Security Engineering, Well Surveys, Dresser Dynamics, Southwestern Industrial Electronics, Hermetic Seal Transformer Co., and Turbodrill division.

Gasser

William Porch has been appointed to head new offices for the direct sales of De Laval Separator Co.'s industrial products in the New York City area. This function had been performed by the Turbine Equipment Co. Porch was formerly De Laval's Eastern division industrial sales manager.

He joined De Laval in 1945 as a Chicago branch field engineer. In 1946, he served as a sales engineer in the Minneapolis area, and was appointed manager of the Oil Purification division in 1952. In 1957 he assumed his present position.

Porch

Leon B. Wohlgemuth has been appointed general sales manager for the Tubular Products division of The Babcock & Wilcox Co. He was formerly sales manager of middle states district sales offices.

Wohlgemuth joined the Tubular Products division after graduation from the University of Pittsburgh in 1936. In 1939 he was made salesman in the Chicago district. In 1950 he became district sales manager. He was named sales manager—middle states in 1955, supervising the division's St. Louis, Milwaukee, Cincinnati and Chicago district sales offices.

Wohlgemuth

Noel S. Chamberlin has been named head of the newly created Chemical Process department for Graver Water Conditioning Co. He brings to his work a background of 27 years experience in practical and theoretical chemical processing, including practical plant operation and liquid treatment problems.

Chamberlin is a chemical engineering graduate of the University of Pennsylvania. He studied at Rutgers University and was an instructor there. He is an active member of many chemical engineering, water and waste treatment associations.

Chamberlin

Frank J. French has been named vice president of Allied Chemical Corp.'s General Chemical division. He will be in charge of the division's production, mining, purchasing and industrial service activities. A veteran of 29 years with the company, he has been director of purchases since 1952.

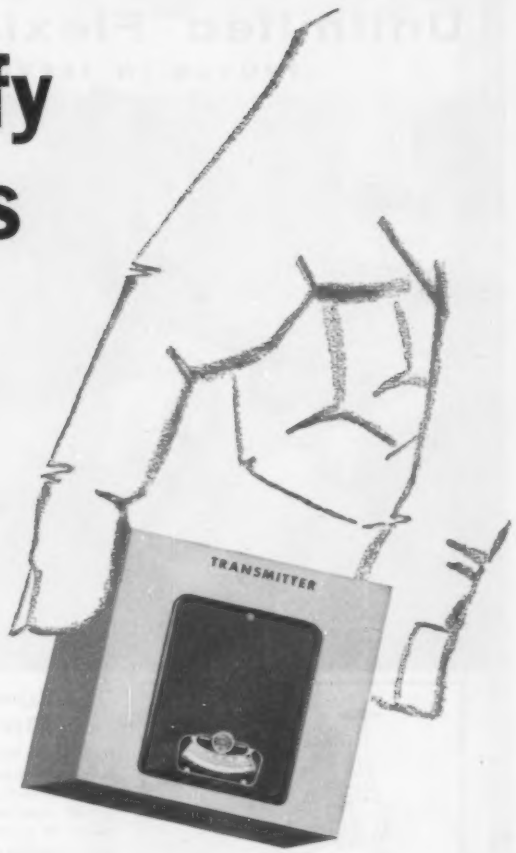
He started with General Chemical as a control chemist at the company's Hudson River Works in Edgewater, N. J.

He has held various technical positions at the division's Laurel Hill, N. Y., research laboratory; Delaware works, Mar-

French

How to simplify control problems

Keep systems flexible, carry small inventory, cut maintenance cost with the **Bailey Building Block Method** of instrumentation and control.



What is the Bailey Building Block Method? It's using standardized Bailey measuring, transmitting, and controlling components and combining them into any system you need. Components can be added as needed . . . removed and reused elsewhere . . . recombined into another system when the need changes. It's flexibility plus!

It's all based on the simple fact that a Bailey instrument or control component doesn't care if the measured variable is steam flow, tank level, or tower temperature, to pick just three examples. System components—transmitters, receivers, relays, selector stations, power units—are standardized for multi-purpose use.

A spare component can be used in any one of many systems. Gone are delays waiting for shipments of special parts. Gone are large inventories of spares and parts. Simplified is the training of men for maintenance.

There are many exclusive features and advantages of the individual components used in the Bailey Building Block Method. And there's much more to the Building Block story itself.

For further details, call our local district office or write us at Cleveland. Our engineers will be glad to prove how the Building Block approach will save you money and simplify your instrument and control problems.

G36-1

BAILEY BUILDING BLOCK METHOD

BAILEY METER COMPANY
1043 IVANHOE ROAD, CLEVELAND 10, OHIO
In Canada—Bailey Meter Company Limited, Montreal

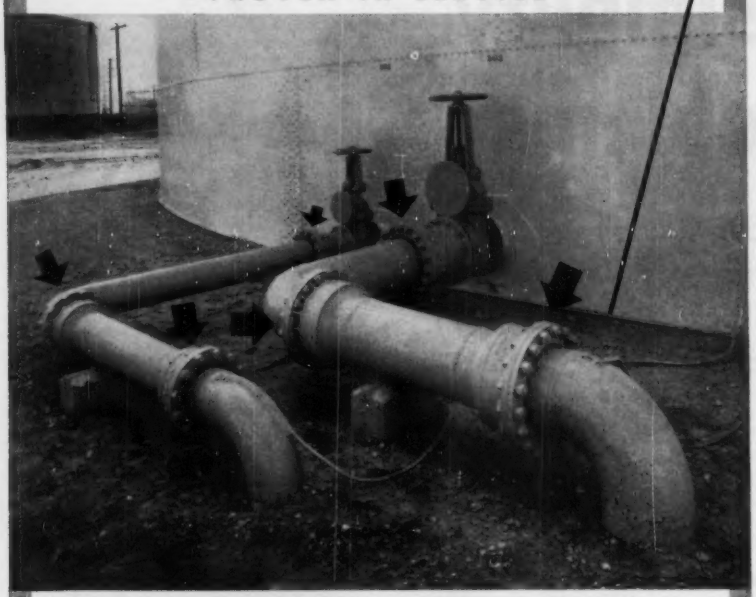
RESULTS IN: FLEXIBILITY, SIMPLICITY, ECONOMY

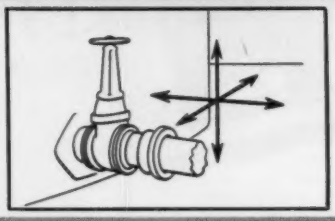
BAILEY METERS

For more data on advertised products, use Readers' Service Cards, last page.

Unlimited Flexibility!

—PROVEN IN SERVICE





Allows 6-Way Movement!

Freedom of movement in any direction is readily possible with these *ball joint connections* of 12" pipe (right) and 8" pipe (left) to 80,203 bbl. tank shown in above photo. (Photo: SHELL OIL COMPANY, Dominguez Refinery, Wilmington, Calif.)

Barco Ball Joints—

provide complete protection against FIRE, EARTH SHOCK, TANK SETTLING

The rapidly increasing use of Barco's new large size Flexible Ball Joints in California, and other locations, is significant for several key reasons:

1. **Fire-Safe. The joints have passed rigid fire and water spray tests.**
2. **Unlimited flexibility and movement.**
3. **Long service life without maintenance.**
4. **Joints insulate against electrolysis as well as provide movement in all planes.**

Such installations protect piping, valves, and tanks from earth movements, shifts, shocks, and earthquakes. They allow for *tank settling* or *tilting* as well as for *thermal expansion* or *contraction of piping* leading to tanks without creating strain. In case of fire, the joints are "fire safe."

For detailed information, WRITE FOR CATALOG 215B. Joints available in steel with flanged or welding ends. 15° angular flex.

PRODUCTS BACKED BY EXPERIENCE BARCO ANNIVERSARY 1908 50TH 1958

BARCO MANUFACTURING CO.

5421 Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Rotary Joints

In Canada: The Holden Co., Ltd., Montreal

Suppliers . . .

cus Hook, Pa.; New York office; Baton Rouge, La., works; and Baker & Adamson works, Marcus Hook, Pa.

French is a graduate of Lehigh University where he received a B.S. degree in chemical engineering in 1932.

Morgan

Andrews

CONSOLIDATED ELECTRODYNAMICS CORP. has appointed **T. Phillips Morgan** Company controller. Also promoted was **Carl W. Andrews**, chief accountant, to assistant controller.

Morgan, controller of the company's Systems division the past four months, will have responsibility for corporate and divisional accounting. Andrews will continue to have responsibility for the central accounting and tabulating operations.

Prior to joining Consolidated in March of this year, Morgan, a Stanford University graduate, was an industrial accountant with the Missile Systems division, Lockheed Aircraft Corp.

Andrews held accounting posts with various California firms before joining Consolidated as an accountant in 1952. He has B.A. and M.A. degrees in business administration.

ALLIS-CHALMERS MANUFACTURING CO. has named **Ralph L. Haney** manager of the Philadelphia district, and **Charles E. Dandois** manager of the Allentown, Pa., district of the company's Industries group.

Haney had been manager at Allentown since November 1956. He is an electrical engineering graduate of Lehigh University.

Dandois had been a sales representative in the Allentown district since January 1957, and has been with Allis-Chalmers since 1949. He is a mechanical engineering graduate of Pennsylvania State College.

ACF INDUSTRIES, INC., has elected **L. Rene Gaiennie** vice president of industrial and public relations. He joined ACF in September, 1957 as director of industrial and public relations. His new duties will encompass labor relations, public relations, personnel, wage and salary administration, security, safety and employee benefits.

Gaiennie has B.A. and Ph.D. degrees in psychology from Washington University, and a M.S. degree from the University of Wisconsin. He has a M.B.A. degree from the University of Chicago.

PENNSALT CHEMICALS CORP. has named **Robert R. Pierce** manager of the Corrosion Engineering Products department. He will be in charge of manufacturing, sales and development for the company's product line.

Pierce will have headquarters in Na-

The payoff comes at high temperatures

You can look for long service life when you use the Bethlehem Continuous-Thread Stud in refinery bolting. That's because it is engineered to resist both elevated temperatures and high pressures. Since the stud has no point of thread runout, it is impossible for stresses to concentrate at any given area. Instead, any stresses which might cause premature failure are more evenly distributed over the full working length of the stud.

The Bethlehem Quenched Nut, used with the continuous-thread stud, is made from 0.40 to 0.50 carbon steel. In the larger sizes, the nut is formed by forging and extruding hot steel; it is then quenched and tempered before tapping. This gives the nut the strength to outperform practically any stud or bolt on which it may be applied.

For low cost bolting, use the Bethlehem Continuous-Thread Stud, with Quenched Nuts, in all of your high temperature installations. For full details, get in touch with the nearest Bethlehem sales office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

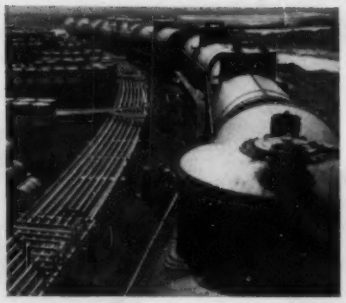
On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more data on advertised products, use Readers' Service Cards, last page.

refining of your by-products



The facilities and experience of Truland may be employed advantageously for the economical upgrading and disposal of solvent mixtures and organic by-products. Our technically trained personnel are available to discuss the refining of any solvent mixture or organic by-product.

Send *for new booklet which describes our operation.*

TRULAND CHEMICAL COMPANY

EAST RUTHERFORD, NEW JERSEY

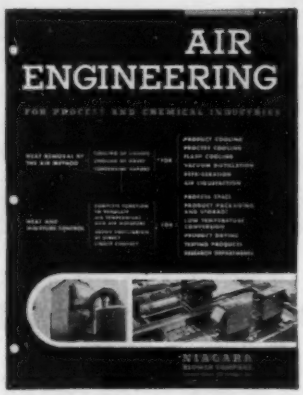
Division of The Trubek Laboratories

TRULAND

AIR ENGINEERING by NIAGARA

- AIR CONDITIONING with precise regulation of air temperature and air moisture for processing, for product drying, packing, storing, low temperature conversion, for testing and research.
- "NO FROST" REFRIGERATION for food and low temperature conversion, for testing and operations at extreme low temperatures; for moisture control below the freezing point of water.
- AFTER COOLING and air drying for large air and gas compressors and AIR LIQUEFACTION.
- COOLING ENGINES, COMPRESSORS, HYDRAULIC PRESSES.
- COOLING QUENCH BATHS, FURNACES, INERT ATMOSPHERES.
- COOLING ROLLS, WELDERS, DRAWING OR EXTRUSION DIES.
- PRODUCT AND PROCESS COOLING CHEMICALS OR INTERMEDIATES.
- COOLING LIQUIDS OR GASES IN CLOSED SYSTEMS.
- VAPOR CONDENSING UNDER VACUUM.
- REFRIGERANT CONDENSING.
- ELECTRONIC PROCESS COOLING.

You will reduce your costs, solve your problems of water supply or disposal and get HIGH OPERATIONAL EFFICIENCY with Niagara "Aero" Evaporative Heat Exchangers, After Coolers, Condensers, Air Conditioners or Coolers for these important plant services or processes.



Write for this Bulletin No. 135

High operational efficiency means: precise temperature for improved product and process quality control, heat removal at rate of input, simple operating conditions, real economy in upkeep, sustained full capacity. It means the lowest expense for up-keep.

Write for Bulletin 135

NIAGARA BLOWER COMPANY

Dept. PR-8, 405 Lexington Ave., New York 17, N. Y.

Niagara District Engineers in Principal Cities of U. S. and Canada

Suppliers . . .

trona, Pa., where all activities for this department will be centered starting in September. Formerly in charge of sales for Pennsalt's corrosion engineering products, he has 17 years' experience in plant, technical service and sales management with Pennsalt. A graduate of Oregon State College with a degree in chemical engineering, he has been sales manager for the Corrosion Engineering department since 1951.

COOPER-BESSEMER CORP.'s advertising director for over 35 years, **E. R. Bonnist,** died of a heart attack at his home in Mount Vernon, Ohio, on July 6th. He was 62.

Bonnist directed the company's program of advertising, sales promotion and public relations and was well known throughout the power industries.

WYATT METAL & BOILER WORKS, INC., has added its fourth metal fabricating plant with the purchase of the existing facilites in Corpus Christi. **J. D. High,** whose sales territory has included Corpus Christi for the past 12 years, has been named manager there.

High

High has been with Wyatt since 1933. Since 1946, his sales territory has included Houston. The University of Texas engineering graduate was employed by Wyatt's as a draftsman in 1933 and in turn worked in production and as an estimator going into the sales department in 1936.

SQUARE D CO. has appointed **Robert E. King** distribution equipment sales manager. He will be responsible for all distribution equipment sales programs, including the headquarters sales department, field office liaison, general sales procedures and field engineer training.

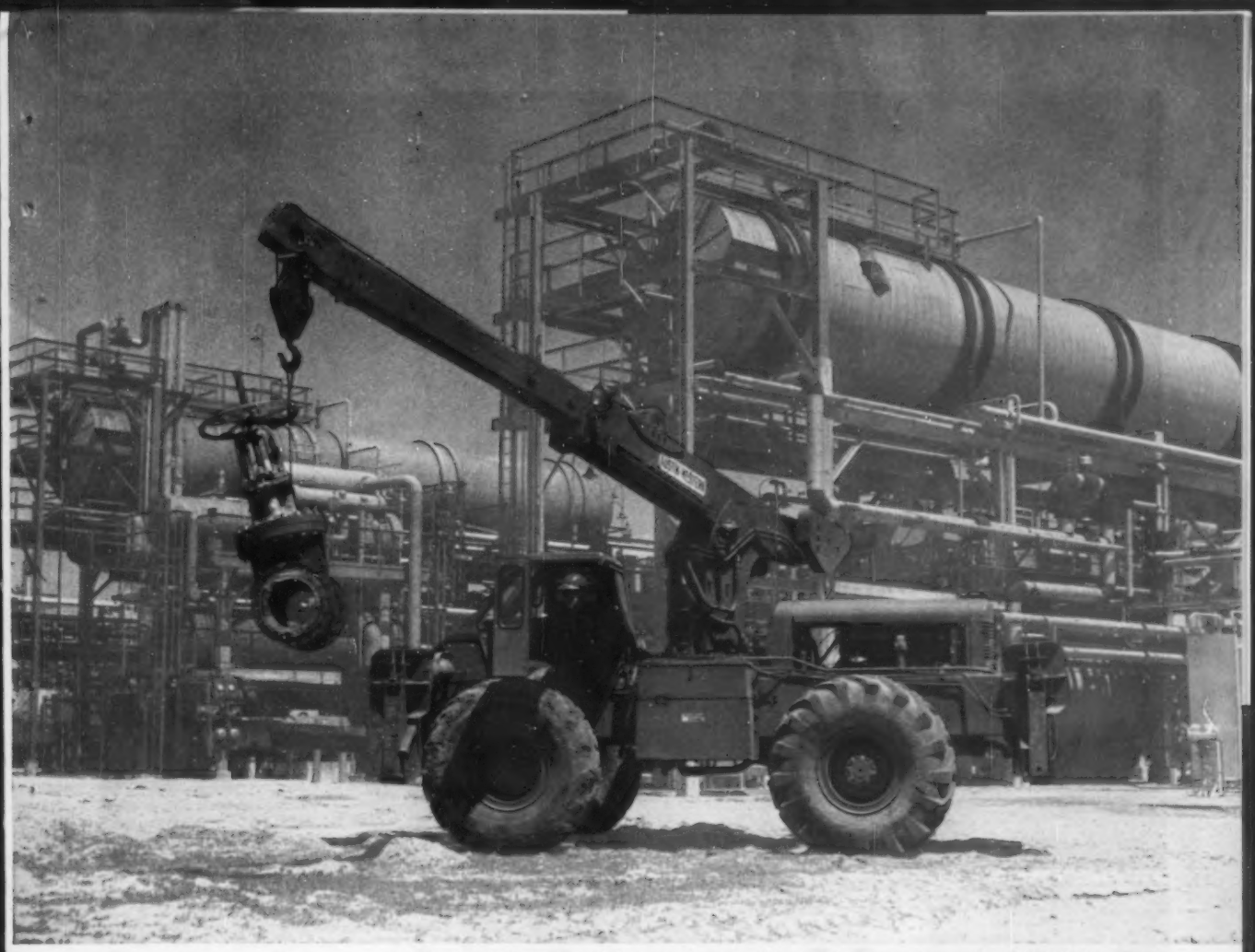
King joined Square D in 1947 upon graduation from Purdue University, and served as a field engineer at Cincinnati from 1948 to 1953. His headquarters will be in Detroit.

MINE SAFETY APPLIANCE CO. is expanding the field sales and service organization of its Technical Products division to provide nation-wide service on instruments and process control equipment. **Nelson W. Hartz,** sales manager of the division, has appointed a staff to serve all sections of the country. **H. B. Stafford** is division operations manager.

THE RALPH M. PARSONS CO. has moved its worldwide headquarters to the 617 West 7th St. Building, Los Angeles. The building was occupied formerly by the Union Oil Co. of Cal. and was leased to Parsons in a transaction reportedly running to several million dollars.

The move consolidated over 1,000 administrative and engineering personnel into a single building, with the remaining Parsons Los Angeles office staff in the Oviatt Building at 617 South Olive St.

Parsons' New York office has moved to



A-W Hydraulic Crane speeds heavy valve assembly to maintenance shop at Sun Oil's Toledo refinery.

Austin-Western Hydraulic Crane proves safe, fast, economical in 3 years' operation at Sun Oil refinery

"Safety was one of the main reasons we purchased an Austin-Western Hydraulic Crane 3 years ago for refinery maintenance. The positive hydraulic control of boom and hoist on this self-propelled precision crane protects personnel and prevents accidents that result from makeshift methods of lifting and moving," we are told by Sun Oil's Toledo refinery.

Dispatcher Records Provide Proof

"Operating time and use are recorded by a vehicle dispatcher. His records provide positive proof that the A-W is safer, easier, faster, more mobile, and less costly than large cranes. It costs less per shift than half of one man's wages.

"We discover new uses daily for it. It goes where big cranes can't. With a ½-yd. bucket attachment, it is even used to pour concrete. It helps maintain our truck fleet, too. It handles engines and tires and, with all-wheel drive, it doubles as a wrecker and towing vehicle.

A-W Does Difficult, Dangerous Jobs Better

"Not only does the A-W do so many difficult jobs better, but it does them more safely and easily. For instance, crane and operator can safely remove heavy gas compressor pistons and transport them to the maintenance shop in 1 hour. This saves 2½ man-hours plus 2 hours' time for truck and driver.

"Our big 10-ton crane couldn't reach a 1000-lb., 6-ft.-long crude oil pump element. But the A-W, with all-wheel steering, maneuvered right up to the pump, removed the element, and delivered it ¼ mile away in less than an hour.

"The A-W is so useful we hired a night operator. The crane pays for his wages with the time it saves by preparing jobs for the next day.

Works 500 Shift-Days per Year

"Our A-W averages two shifts daily—a total of 500 shift-days a year. Often it works a third shift for overtime work or to shorten downtime on equipment. It's easy to operate. A number of our maintenance men can put it through its paces.

"This inexpensive hydraulic crane is another modern tool to help our men do their work more safely, more efficiently, and at lower cost!"

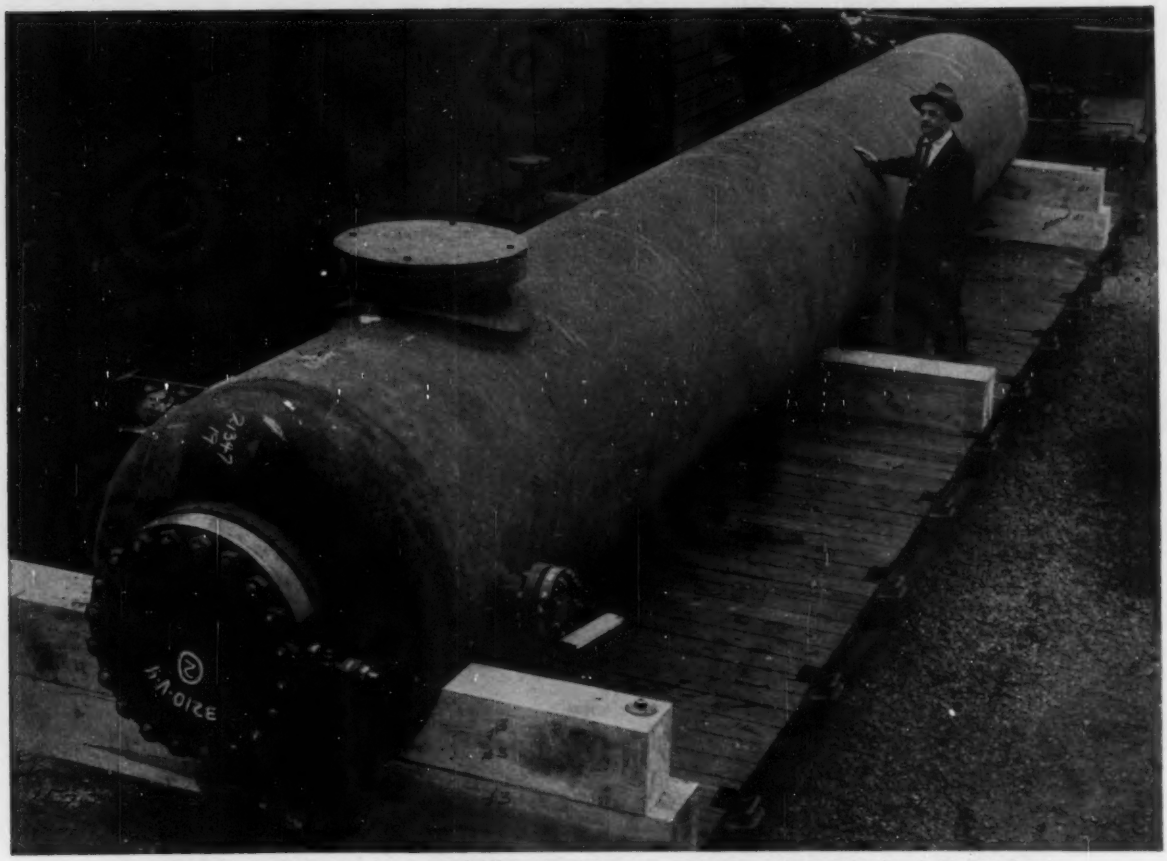
Send for the complete Sun Oil Toledo refinery story—Gould Certified Report No. 5712. Write today.

Austin-Western CONSTRUCTION EQUIPMENT DIVISION, AURORA, ILL.

BALDWIN · LIMA · HAMILTON

Power graders • Motor sweepers • Road rollers • Hydraulic cranes

BALDWIN BLH LIMA-HAMILTON



NEWPORT NEWS BUILT two 39'-7" horizontal gas scrubbers, such as this, for J. F. Pritchard & Co. They were made of ASTM-A212 Grade B fire box steel, with structural mesh steel interiors.

Gas scrubber made of 2⅞" steel

Newport News builds almost any type of pressure vessel and other heavy process equipment

Here is one of two horizontal gas scrubbers recently built for an operating pressure of 1800 psi at 300°F.

Newport News made both vessels from fire box steel, 2⅞ inches in thickness. We formed and automatically welded this steel into sections having a diameter of only 4 feet.

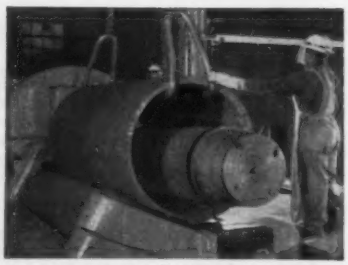
Rolling thick steel to this small diameter...no easy accomplishment, as you probably know . . . demonstrates the sort of jobs Newport News takes in stride.

Almost any type of heavy processing equipment is readily constructed by Newport News in a 225 acre plant comprising huge, fully equipped fabricating and machine shops, foundries, forge and die shops, heat treating and allied equipment as well as complete test facilities.

Newport News shop erection of fabricated units helps to speed assembly at your plant site.

Get a bid from Newport News on your present or future projects. Get the benefit of specialized production techniques. Look over the many ways in which Newport News can help you . . . write for "Facilities and Products", a very interesting booklet. It's yours for the asking.

ENGINEERS Desirable positions available at Newport News for Designers and Engineers in many categories. Address inquiries to Employment Manager.



ROLLING 2⅞" STEEL for gas scrubbers. The steel, in a hot condition, was formed on the heavy bending equipment shown here. It will cold roll mild steel up to 3 inches thick, and will hot roll any grade of steel up to a thickness of 5 inches.

Newport News Shipbuilding and Dry Dock Company
Newport News, Virginia

Suppliers . . .

larger quarters in the Seagram Building, 375 Park Ave. The last of three moves took place in France, where Parsons' office was moved to 41 Avenue George V, Paris 8.

SQUARE D CO. has appointed **Mitchell P. Kartalia** general manager of the Marketing division. He will be responsible for all Marketing division programs, including distributor relations, field office operations, national advertising, market research, product development liaison, and export activities.

Kartalia, who has been sales manager of Square D's Distribution Equipment division, will make his headquarters in the Detroit executive offices, reporting to the president. He succeeds Frank Roby, who has resigned.

A graduate of the University of Cincinnati, Kartalia joined Square D in 1940 as a sales application engineer and successively held various executive sales positions.

Owen

Nuckolls

W. A. LAMONS CO., Houston, has been purchased by **Bob Owen** and **Paul Nuckolls.** The company name has been changed to **Lamons Metal Gasket Co.**

Owen, the newly elected president, is a mechanical engineering graduate of the University of Texas and a registered professional engineer in Texas. For the past ten years he and Nuckolls were sales representatives with a leading packing manufacturer. Nuckolls has been appointed vice-president. He has a chemical engineering degree from Auburn University.

W. A. Lamons, former owner and founder of the business, will stay with the company for a limited time as a consultant. The other employees and supervisory personnel will remain intact.

BIGELOW LIPTAK CORP. has established a new Mid-Continent sales office at 214 Thompson Bldg., 20 E. Fifth St., Tulsa 3.

The office will serve the petroleum and petrochemical industries and will be headed by **John A. Knebel.** Territory covered will include Missouri, Kansas, Oklahoma, the Texas Panhandle, and St. Clair and Madison Counties in Illinois.

ATLAS POWDER CO. has made several major changes among top-level personnel, including the election of President **Ralph K. Gottshall** as chairman of the board and president. He succeeds **Isaac Fogg,** who has retired. Fogg will remain as a director, member of the finance committee, and chairman of the committee on audit.

The board also announced the election of **Edward J. Goett,** senior vice president, to executive vice president. Other changes announced included:

Edward J. Massaglia, general manager

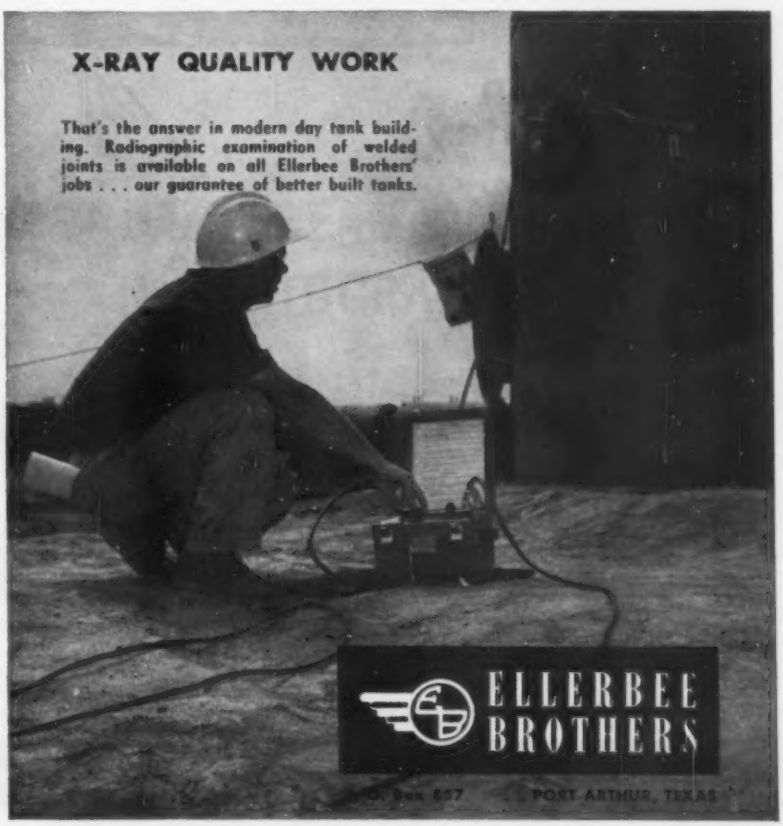
Only EVER-TITE The Best In Quick Couplings can make all these claims

Superior quality —precision machined
Uniform wall thickness —no weak spots
Extra heavy reinforcing rim
Larger diameter cam ears for longer service life
Extra Hi-Strength forged handles —greater economy
Stainless Steel pins —greater safety and longer service
Uniform heavy wall thickness —no weak spots
Recess retains gasket in coupler and assures proper placement
Superior quality —precision machined —accurate tolerances

EVER-TITE COUPLING CO. INC., 254 WEST 54th STREET, NEW YORK 19

X-RAY QUALITY WORK

That's the answer in modern day tank building. Radiographic examination of welded joints is available on all Ellerbee Brothers' jobs . . . our guarantee of better built tanks.



ELLERBEE BROTHERS

Box 857 PORT ARTHUR, TEXAS

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

for operations of the chemicals division, elected vice president and general manager of the newly-consolidated chemicals division; and **Robert J. Reilly,** assistant treasurer, elected treasurer and secretary, succeeding **Preston W. Parvis,** who also has retired. Parvis will remain a member of the board and the committee on audit.

John H. Leary, assistant to the president, was elected assistant treasurer and assistant secretary, and **Norman E. Miller,** company controller, was made an officer.

Officers re-elected were vice presidents **James R. Frorer, Charles C. Gammons, William C. Lytle,** and **Arnold J. Fiedler,** assistant treasurer and assistant secretary.

INFILCO INC., of Tucson, Ariz., has moved its San Francisco office to 1485 Bayshore Boulevard. **F. S. Howard** is in charge. **N. N. Cahan,** until recently representative in New York district for Infilco, has established an office in Syracuse. Address is P. O. Box 231, Syracuse 1, N. Y.

LAUREN B. HITCHCOCK ASSOCIATES, chemical engineers, have established offices in the Lincoln Building, 60 East 42nd Street, New York, to conduct industrial research and development counselling, commercial chemical development, and technical and economic investigations. They specialize in technical planning, organization and new product development for the chemical process industries. **Dr. Hitchcock** was formerly vice president of The Quaker Oats Chemicals department, president of National Dairy Research Laboratories, and president of the Air Pollution Foundation.

BLACK, SIVALL & BRYSON, INC.'S Oilfield Equipment division has promoted **M. Steve Worley** to chief development engineer. A graduate of Oklahoma State University with a M.S. degree in chemical engineering, Worley joined the company in 1951, became product supervisor for dehydrators and desulfurizers in 1952, and later became project supervisor in the development group. As chief development engineer he will be responsible for the administration of the oilfield and gas processing equipment development program, including supervision of the company's research and development facility at Oklahoma City.

MAGNET COVE BARIUM CORP. has promoted **David G. Willis** from publications manager to advertising manager. He will also retain his responsibilities as publications manager.

Willis

Willis has had varied experience in writing, editing, and advertising, having served as copywriter, publicity director, and account executive for various Houston advertising agencies.

The University of Houston graduate served three years as a member of the editorial staff of PETROLEUM REFINER. He is a member of the Information committee of the Houston Chamber of Commerce and a member of the board of directors of the Southeast Texas Industrial Editors.

BORG-WARNER CORP.'S Ingersoll Steel division has elected **Harold G. Ingersoll, Jr.,** president and general manager. He was formerly executive vice president and general manager.

Ingersoll joined the division in 1951 after attending Wabash and Knox Colleges and the Harvard University Graduate School of Business.

MINNEAPOLIS-HONEYWELL REGULATOR CO.'s Boston division has appointed **C. B. Harrison** marketing manager. He will direct sales proposals to military and industrial customers, and head advertising and sales promotion campaigns.

J. A. Vitka has been appointed contract administration manager, directing the work on production contracts. He previously was manager of government contract administration.

W. A. Rote, formerly chief engineer, will be director of engineering, heading research and development, pre-production, product and special engineering activities.

CONSOLIDATED ELECTRODYNAMICS CORP. has appointed **Harold S. Davis** sales manager of the DataTape division. He was a sales engineer, sales manager, and marketing manager the past three years, and was a service engineer and sales engineer with General Electric Co. from 1941 to 1955. Davis has a B.S. degree in electrical engineering from the University of Colorado.

UNITED STATES RUBBER CO.'s Naugatuck Chemical division has named **Dr. Wesley S. Coe** director of research and development. He replaces **Dr. D. Lorin Schoene** who has been appointed assistant director of research and development for U. S. Rubber.

Dr. Coe will supervise all research and

Increase drafting efficiency

30%

with the NEW Kuhlmann line!

Kuhlmann Drafting Machines offer accuracy within .005" over the entire board! Unique features such as Independent Base Line Return and Reciprocal Head Numbering have led many of the country's leading engineering facilities to choose Kuhlmann drafting machines, tables, and methods to increase efficiency and accuracy.

WRITE FOR BATTELLE INSTITUTE REPORT, "How To Save Money and Manpower in Engineering", and learn how a Kuhlmann equipped drafting department will make full use of your engineering and design manpower.

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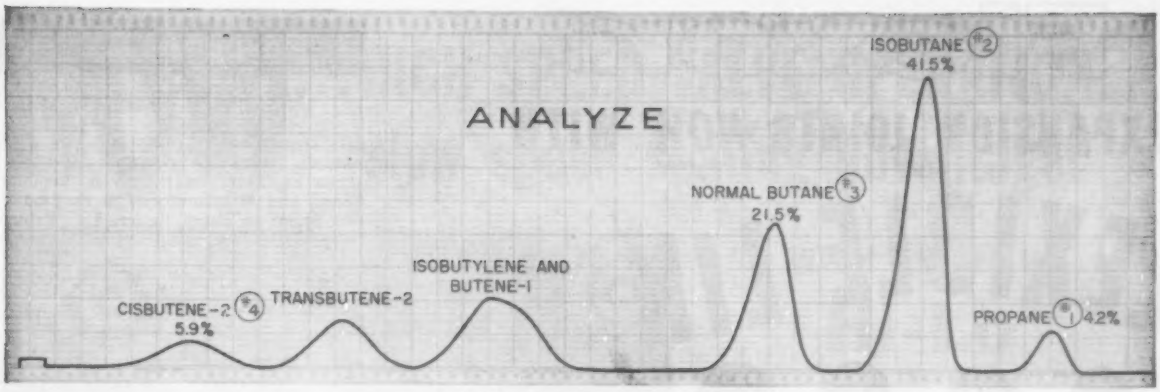
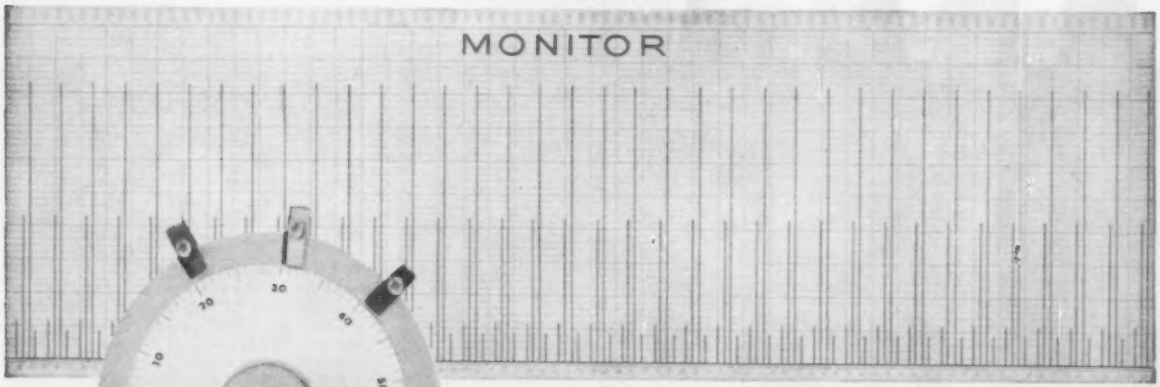
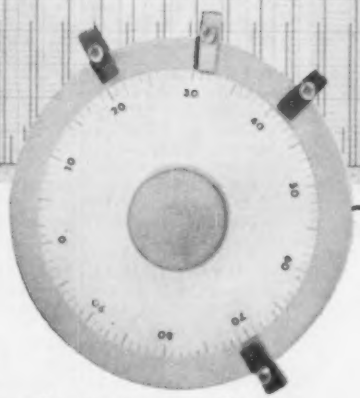






Top: Model 184 fractogram in one mode of chart presentation shows quantitative analysis of components from typical refinery stream.

Bottom: Percent concentration of four preselected components from fractogram above is directly shown on bar chart.

Left: Timing dial of programmer is designed for fast set-up and calibration, also to indicate peaks.

A New Instrument for

AUTOMATIC PLANT STREAM ANALYSIS BY GAS CHROMATOGRAPHY

After more than a year of field tests with ten leading oil and chemical companies, a new process vapor fractometer is now commercially available for multi-component analysis and monitoring of process streams.

The Model 184 is simple, versatile and reliable. Long term accuracy under plant conditions was a prime design consideration. Reproducibility is unequaled. Every safety feature has been incorporated.

Thanks to its in-plant evaluation by top instrumentation and process control engineers, the new P-E Model 184 can be put on stream with confidence—next year's afterthoughts are already built in.

For more information write us at 880 Main Avenue, Norwalk, Conn.

Model 184 consists of analyzer unit in explosion-proof housing, panel mounted programming and recording units. Instrument monitors up to four components directly on bar chart.

INSTRUMENT DIVISION

Perkin-Elmer *Corporation*

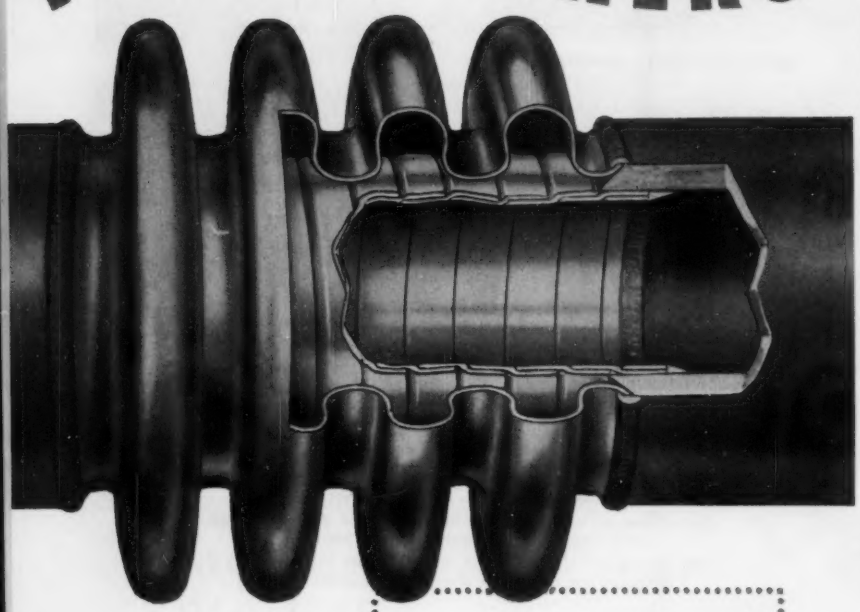
NORWALK, CONNECTICUT

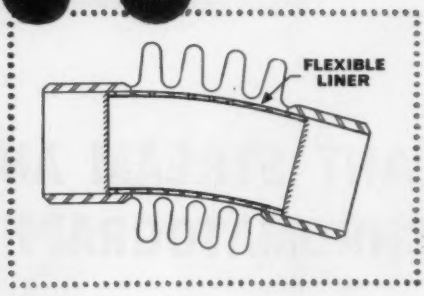
For more data on advertised products, use Readers' Service Cards, last page.

Flexon®

EXPANSION JOINTS *NOW* WITH

FLEXIBLE LINERS



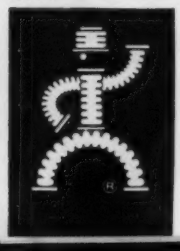


Lateral or angular motion without flow reduction of conical type liners

No more need to specify oversize expansion joints to allow for the flow reduction through an ordinary conical liner! Now you can get Flexon Expansion Joints with flexible liners that give full flow. Easier to install, too, because flow can be in either direction. A section of smooth interior, Flexon stainless steel hose forms the liner—cuts flow turbulence, reduces carrier temperature and permits full pipe movement either laterally, angularly, or axially. The cost is no more than for conical sheet liners.

Write today for facts about this new Flexon development—and your copy of the 28-page Flexon Expansion Joint Design Guide, the complete handbook for solving every problem in pipe motion.

EJ-230



Flexonics
corporation

EXPANSION JOINT DIVISION • 1336 S. THIRD AVENUE, MAYWOOD, ILLINOIS

EXPANSION JOINTS · METAL HOSE · NON-METALLIC HOSE · BELLOWS · AIRCRAFT COMPONENTS

Suppliers . . .

development work at the division's main research laboratory in Naugatuck, Conn., at its experimental farm in Bethany, Conn., and at laboratories in its production plants at Baton Rouge, La.; Painesville, Ohio; Los Angeles; and Gastonia, N. C.

Dr. Coe joined the company as a research chemist in its general laboratories in 1936 after receiving a Ph.D. degree in chemistry from the University of Illinois.

KELITE CORP. has appointed **Frank W. Weldon** district sales manager. He previously served for 12 years with Oakite Products, Inc.

Weldon will be responsible for Kelite sales in the Dallas district, comprising northwestern Texas, Oklahoma, southern Kansas, southwestern Missouri, northern Arkansas, western Tennessee and Kentucky, and northern Mississippi (with headquarters in Dallas.)

BAILEY METER CO. has named **R. T. Cathey** district manager of the company's Dallas district. Cathey holds a B.S. degree in mechanical engineering from Clemson College. He joined Bailey in 1947.

NORTON CO. has appointed **James W. Glasford** a refractories engineer. He will call on and service accounts in Texas, Oklahoma, Louisiana, Arkansas, New Mexico, Colorado and Kansas with headquarters in Houston.

Glasford graduated from the University of Illinois with a degree in ceramic engineering. He joined Norton in 1956 following graduation.

DE LAVAL STEAM TURBINE CO. has appointed **Rear Admiral Mitchell D. Matthews, USN (Ret.)** manager of the Service and Repair division.

Admiral Matthews, a 1927 graduate of the U. S. Naval Academy, retired from the U. S. Navy in 1957 after thirty years of service to join the De Laval organization.

TUBE TURNS has promoted **Jack D. Tolliver** to sales manager for the company's Eastern region. He will be responsible for sales operations covered from offices in New York, Philadelphia, Pittsburgh, Chicago, Louisville and Atlanta, and will have his own office in Louisville.

THE DE LAVAL STEAM TURBINE CO. has named **W. H. Mouquin** manager of its New York district office. The new office will provide direct sales and service facilities for De Laval products formerly handled by the Turbine Equipment Co., New York.

Mouquin joined De Laval in 1955 as manager of the Chicago district office. He attended Lehigh and Columbia Universities.

DOLLINGER CORP. has named **Lewis L. Dollinger, Jr.,** president of the company. He had been vice president and sales manager of the firm. Dollinger graduated from Cornell University in 1938 with a degree in mechanical engineering.

CONSOLIDATED ELECTRODYNAMICS CORP. has formed a German subsidiary to serve as a central sales and service facility in Western Europe and the United Kingdom.

Known as Consolidated Electrodynamics Corp., GmbH, the wholly owned sub-

NOW...HIGH SPEED VALVE OPERATION... slow speed seating Advantages

The illustration shows a style HM LimiTorque with "Hi-Lo" attachment mounted on a W-K-M 16" series conduit valve for operation on a large oil pipeline. The particular Unit causes the valve to open the full 16" of travel in 12.5 seconds, and close the valve through the same distance in 2 minutes and 40 seconds.

WITH THE NEW Hi-Lo LimiTorque ATTACHMENT

LimiTorque now has available a complete new design "Hi-Lo" 2-speed attachment, which is a magnetic clutch actuated gear reduction unit. The "Hi-Lo" attachment is mounted between the motor and the LimiTorque housing, and permits operation at either of 2 "speeds", and is capable of changing speeds under load. It permits hi-speed valve operation and still retains the slow speed seating characteristics required by most valves.

The "Hi-Lo" attachment permits as high as 18:1 ratio in speeds, and is controlled either by pre-set limit switches or relays mounted in the LimiTorque Operator or by other control devices located on associated equipment furnished by us or others.

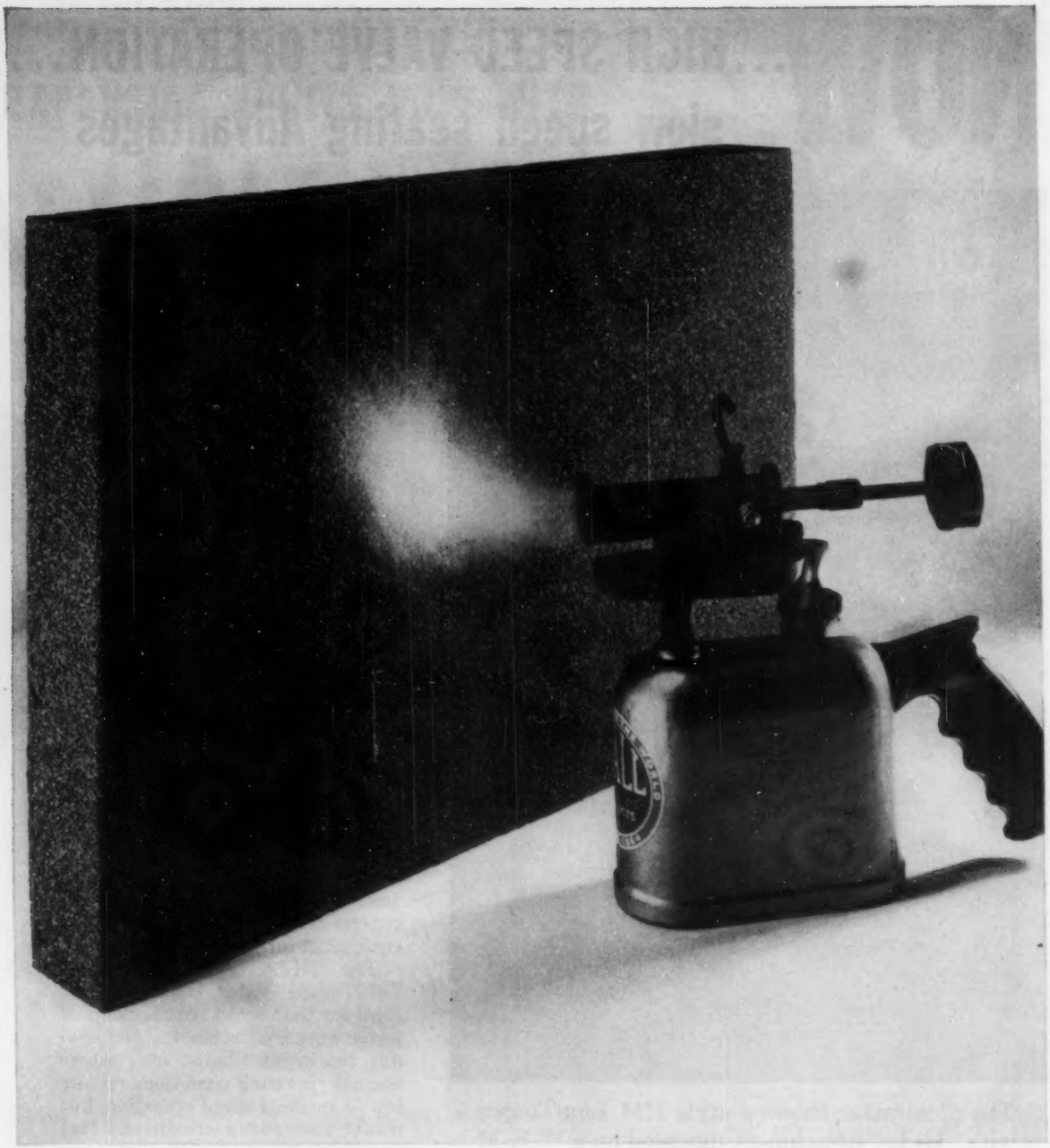
The "Hi-Lo" attachment to the LimiTorque Valve Unit makes it ideal for the special requirements of water works, oil refineries, and sewage treatment plants, etc., where normal operating conditions require low or medium speed operation, but under emergency conditions fast speed operation is a must. Line surge or hammer is reduced under emergency hi-speed operation by changing to low speed operation prior to seating. Further information available from Philadelphia Gear Corporation.

LimiTorque®

There is no Substitute for Limitorque

PHILADELPHIA GEAR CORPORATION
ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.
Offices in all Principal Cities
INDUSTRIAL GEARS & SPEED REDUCERS • FLUID MIXERS
Limitorque Corporation • Philadelphia

For more data on advertised products, use Readers' Service Cards, last page.



. . . always an insulation investment; never an insulating expense

FOAMGLAS® CAN'T BURN

Most insulations are combustible. They create a serious fire hazard in insulated buildings or on piping and equipment. You eliminate that hazard when you insulate with FOAMGLAS. Composed entirely of glass, FOAMGLAS can't burn. There's more to this insulation investment story. FOAMGLAS is waterproof and vapor-proof to insure lasting insulating value. It's dimensionally stable . . . unusually strong . . . acid-proof . . . vermin-proof . . . easy, economical to handle and install. Learn how to make this safe investment in your own insulated buildings, piping and equipment. Write for our latest catalog containing complete specification and application data. PC Glass Blocks are another outstanding building product of Pittsburgh Corning Corporation.

PITTSBURGH CORNING CORPORATION

Dept. Z-88, One Gateway Center, Pittsburgh 22, Pa. • In Canada: 57 Bloor Street West, Toronto, Ontario

Suppliers . . .

sidiary will be located at Weissfrauenstrasse 3, Frankfurt am Main.

A. W. Brandmaier, named manager of the German firm, will continue as European regional manager for the export sales organization of the parent company, which recently moved its European office from Zurich, Switzerland, to the Frankfurt address.

Directing service operations, which will include a staff of company engineers and Frankfurt warehousing facilities, is **Dr. Wolfgang Beyrich** of Mulheim-Ruhr, Germany.

BORG-WARNER CORP.'s Ingersoll Kalamazoo division has named **Dale R. Angle** factory sales representative. He was formerly with the Mac Allister Machinery Co., Indianapolis.

Angle will be responsible for sales of materials handling equipment sold by dealers in the Western district.

REYNOLDS METALS CO. has moved its sales headquarters from Louisville, Ky., to Richmond, Va. All of the company's headquarters functions—including manufacturing, marketing, advertising, research and corporate groups—are now located in Richmond. Unaffected by the move are seven Reynolds aluminum fabricating plants in Louisville.

TRETOLITE CO., division of Petrolite Corp. has anounced several transfers and additions to the company staff of field service engineers.

Wayne L. Brown, Tretolite field service engineer at El Dorado, Kan. has been transferred to Anaco, Venezuela. He has been replaced at El Dorado by **Troy Driver,** formerly a representative at Lindsay, Okla.

LaVern L. Trompke has been named field service engineer at Kimball, Neb.; **Norman J. Ruder** has been assigned to Plainville, Kan.; **James H. Turner** to New Iberia, La.; and **Leigh L. Slade** to Odessa, Texas.

FLEXONICS CORP. has formed an Expansion Joint division, the second of five operating divisions being established under a new organizational plan recently announced.

E. L. Hiter has been named general manager of the new Expansion Joint division. He will be responsible for both production and sales of all expansion joint and compensator products. Hiter was previously Expansion Joint division sales manager.

Key members of the staff are: **R. L. Benton,** factory manager; **J. E. Isenhart,** accounting and office manager, and **R. M. Quick,** assistant division sales manager.

Headquarters of the division will be at the company's Savanna, Ill. plant.

NATIONAL CARBON CO., division of Union Carbide Corp., has established two field sales divisions with headquarters in New York and Chicago.

E. S. Malkin, formerly chemical products field salesman in New York, has been named eastern division manager. He will direct the field activities in sales territories in the eastern U. S.

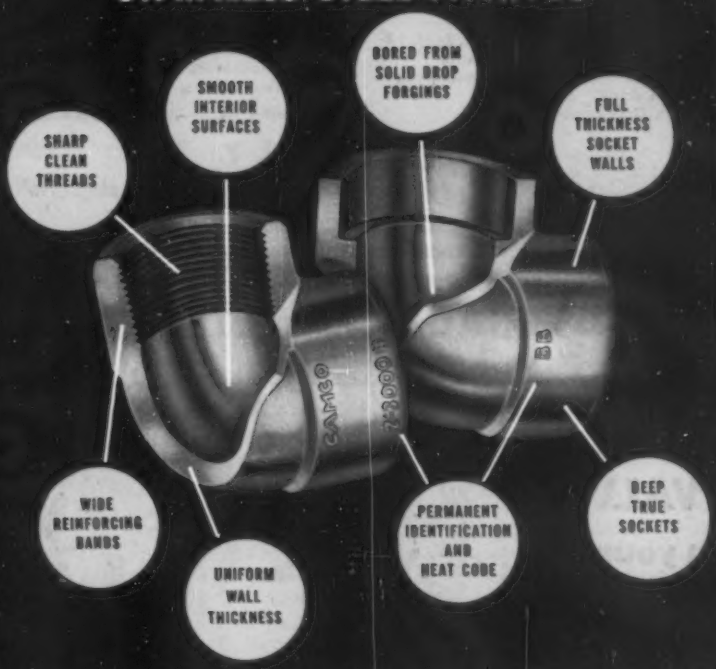
J. F. Brauning, formerly chemical products field salesman in Chicago, has been appointed western division manager. He

SPECIFY

CAMCO

THE Quality LINE IN FITTINGS

2000 Lb., 3000 Lb. and 6000 Lb.
SCREWED and SOCKET WELD
STAINLESS STEEL FITTINGS



Special non-standard fittings furnished to order . . . One source for all your stainless fitting requirements.

Also available—150 lb. screwed fittings and all schedules of buttweld fittings.

CAMCO FITTINGS, INC., 301 State Street
North Haven, Conn.

☐ Catalog Extra Heavy 657.	M&R
☐☐ Catalogs covering complete line.	CE
☐ Furnish address of area distributor.	PR

NAME_____
COMPANY_____
ADDRESS_____
CITY_____ ST._____

THE Quality LINE IN FITTINGS

CAMCO FITTINGS, INC.

No. Haven, Conn.

WEST COAST AGENT AND WAREHOUSE
J. J. GATELEY CO.
8283 Baldwin Street
Oakland 21, California

For more data on advertised products, use Readers' Service Cards, last page.

"PYROMETEERS"

PYROMETER ENGINEERS, BUYERS, EXECUTIVES

attending the PHILADELPHIA **ISA** Show
we invite you to our **BIG PARTY**

SHERATON HOTEL

INDUSTRIAL PYROMETER AND SUPPLY Co. ALTON, ILL. U.S.A.

GRAND BALLROOM

★ 2 NIGHTS . . .
Tues., Sept. 16 and Thurs., Sept. 18
★ See our Gigantic Floor Show
★ Big Bar—All the finest liquors you can drink
★ Big Orchestra—Dancing
★ Big Buffet Supper—All the turkey, Ham and food you can eat
★ Your Caricature by Artist Lenn Redman as a souvenir
★ Beautiful Girls—Side Attractions.

9:00 P. M. TILL ?

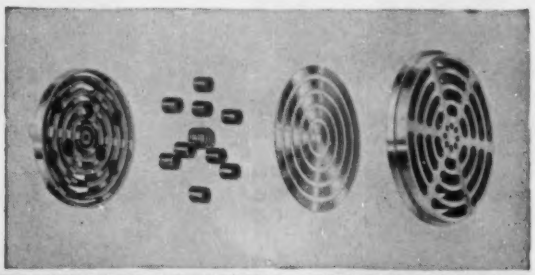
See Our Booth . . . Number 942 Philadelphia Convention Hall
Write for invitation

World's largest manufacturer of Pyrometer and Thermocouple Extension Lead Wire

INDUSTRIAL PYROMETER AND SUPPLY COMPANY

ALTON, ILLINOIS, U.S.A.

VOSS VALVES in your machine mean



LESS MAINTENANCE, FEWER SHUTDOWNS

for your compressor. (air, gas, ammonia)

- up to 40% more valve area • minimum pressure loss • higher efficiency
- less power consumption • normal discharge temperature
- quiet, vibration-free • utmost safety • lower operating costs

VOSS VALVES are made to specification, machined from solid stock (not cast) — VALVES and PLATES are of heat-treated alloy or stainless steel; PLATES are machined, not stamped, and ground for precise close-tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. SPRINGS, of heavy rectangular sections and large diameters, add to dependability and safety.

Our detailed proposal will be sent without obligation. Send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street, New York 54, N. Y.

Suppliers . . .

will be responsible for sales operations in the western half of the country.

J. M. Brown, former chemical products salesman in Birmingham, will assume Brauning's responsibilities in the Chicago area. **T. W. Manchester** will become chemical products salesman in Birmingham.

D. S. Glass, previously a member of the chemical products headquarters marketing staff in Cleveland, has been named to the position in New York formerly held by Malkin.

GROVE VALVE AND REGULATOR CO. has added **Dale DeLong** and **R. F. Hughes** to its sales engineering staff. DeLong will be assigned to the New Orleans area, and Hughes will be headquartered in Tulsa.

The company also transferred **B. W. Bowden** from its Houston office to Lafayette, La.

CRANE CO. has appointed **David H. McClain** general manager of its branches. He has been administrative assistant for the branches since January, 1957.

McClain joined Crane Co. in 1929 at Philadelphia. In 1942 he was named office manager at the Boston branch, and three years later joined the control division in Chicago. He was assigned to that division until his transfer to the branch division in 1957.

NORTON CO.'s Electro-Chemical division has appointed **Frederick J. Rutland** resident manager of the company's Chippawa, Ontario, electric furnace plant.

Edward D. Porter has been named supervisor of technical services of the division.

Rutland was formerly manager of sales engineering and has been with the company since 1935. Porter joined the Norton research laboratories in 1948 and later worked on special development projects.

DRESSER INDUSTRIES, INC.'s manufacturing division has promoted **Charles G. Thomas** to acting manager of purchases. He joined Dresser in 1942 and has held positions as welding engineer, chief manufacturing engineer and assistant works manager. He is an electrical engineering graduate of Pennsylvania State University.

ALLIED CHEMICAL CORP.'s Solvay Process division has appointed **Peter J. Cambourelis** technical assistant to the director of product development. A graduate of M.I.T. Cambourelis holds a B.S. degree in business and engineering administration. Before joining Solvay, he was a sales engineer for Rem-Cru Titanium, Inc.

U. S. STEEL CO.'s Oil Well Supply division has named **Thomas J. Slattery** assistant district engineer at Casper. He was employed by the company in 1957 as a junior engineer at Abilene, Tex. He graduated from Marquette University with a B.S. degree in engineering.

JONES & LAUGHLIN SUPPLY DIVISION has appointed **W. J. Doerfler**, store manager at Russell, Kan. He joined the company as a storeman at Chase, Kan. in 1952 and was promoted to store manager there in March, 1958.

OAKITE PRODUCTS, INC., has named **William A. Baltzell** industrial sales manager. He will be responsible for the work of all company's divisions and technical serv-

How you can be sure to get the capacity you pay for in a cooling tower...

Thousands of gallons of water pour through a cooling tower every minute. If it goes in hot and comes out cold . . . if it keeps a plant's process water reasonably cool—is it safe to assume that the tower is doing its job . . . that the owner is getting his money's worth out of it?

Definitely not!

A tower may actually be operating at only a portion of the capacity paid for—without the owner's knowledge. Its heat transfer efficiency may fall short of specifications. Operating horsepower requirements may be higher than they should be.

How can you tell?

By conducting thorough field performance tests. But if the tower proves deficient, you can correct it only by increasing horsepower or the size of the tower—or both. Even though the manufacturer stands behind his product, you are put to additional expense, you may lose valuable production because of down time during the reconstruction, and your operating power costs may be increased for the entire life of the tower.

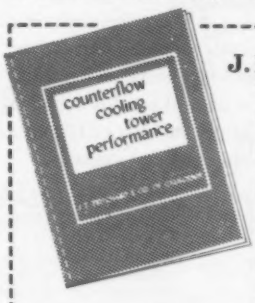
Obviously, the best thing is to *know* the capacity before you buy.

How? Well, you *can* accept the manufacturer's guarantee. But how many manufacturers *really* know? Determining the capability of a cooling tower is an exacting science, requiring highly specialized knowledge of a wide variety of factors influencing performance.

Portions of such knowledge have been published in the past but much has been retained by cooling tower manufacturers as "private and confidential" data. But now, Pritchard has gathered all this information, refined it, added to it field-tested findings from our own research facilities, and arranged it into usable form. This reservoir of knowledge has been published under the title, "Counterflow Cooling Tower Performance," and is available from Pritchard for $3.00. For your copy, mail the coupon below with your check or money order.

No book alone, however, can guarantee cooling tower capacity. That is the responsibility of experienced Pritchard engineers, who translate the information contained in the handbook into cooling tower designs that give you performance, not promises . . . real long-run economy, not first-cost-only economy.

The result is that when you buy from Pritchard, you buy with full confidence that you get what you pay for. You can rest assured that your Pritchard tower will deliver the capacity you specify.



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ice representatives throughout the U. S. and Canada.

Baltzell joined Oakite's field service staff in 1941, was appointed southern division manager in 1946, and became assistant sales manager in 1953. He is a member of the company's board of directors.

H. K. PORTER CO., INC., has appointed **John W. Parker** controller at Refractories division. He has been with the internal audit staff since January, 1957. Parker was previously with Chrysler Corp. and Main and Co. in Philadelphia.

MIDWEST PIPING CO. has elected **Fred J. Blum** executive vice president and secretary. Blum, with the company for 38 years, was formerly vice president and secretary.

ARIES ASSOCIATES has appointed **Gilbert E. Collyer** contract manager. He will be responsible for consulting liaison between the chemical process and electronics industries and the Aries organization in the U. S. He will advise clients on technical and economic consulting problems.

CHICAGO BRIDGE & IRON CO. has changed the name of its Brazilian subsidiary to Chicago Bridge Construcoes Ltda. The subsidiary's former name was Sociedade Chibridge de Construcoes Ltda.

AQUATROL, INC., Houston, has a new building to replace the one destroyed by fire in Houston on April 6. The structure was planned and constructed within three months after the fire, and includes air-conditioned offices and laboratory and new equipment for manufacturing and equipment handling.

M. C. Forbes, president and technical director of the company, reported these promotions: **R. O. Johnson** to technical director, **Howard M. Itz** to service engineer, and **John P. Tognetty** to vice president in charge of production. **Larry Twiford** has been added as a chemist.

ENJAY CO., INC., has named **G. M. Hebert** manager of a newly-created Export Sales division. The new division will consolidate the export of all the company's products.

Prior to his new appointment, Hebert served as Enjay's sales manager for Paramins. He began his career in 1938, after graduation from the University of Illinois, as a petroleum engineer and has been with Enjay since 1949.

SELAS CORP. OF AMERICA'S Frederic O. Hess, president of the company, will receive the Walton Clark Medal of The Franklin Institute for his development of new processes for the industrial use of gas.

He will be awarded the medal, founded in 1926 by the United Gas Improvement Company of Philadelphia, on Oct. 15, at formal ceremonies in Franklin Memorial Hall of the Institute.

Hess has received three awards for his scientific contributions. In 1946, the Amer-

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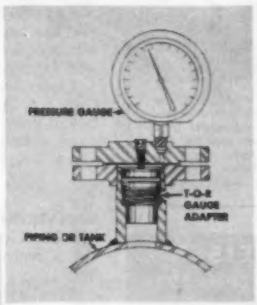

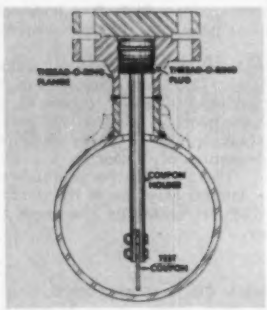

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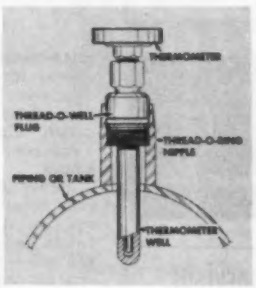

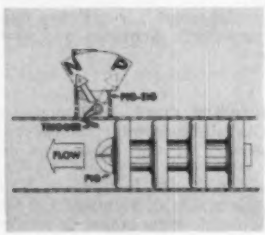

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* * * * * * * * * * * * * * * *

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Petroleum Refinery Engineers

Positions involve technical service and consulting type work for petroleum refiners. Requires chemical engineers with several years experience in refinery process engineering, operations, and/or economic analysis. Positions offer a wide variety of work assignments in an expanding technical activity that works with Sales, Research, Refinery, and company management problems. Also affords opportunity for industry-wide contacts with refining and process companies and for using initiative and individual expression to increase responsibility. Location in Detroit suburb offers ideal professional environment with a choice of city or suburban living. Send resume to:

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POSITION WANTED

CHEMICAL ENGINEER—B.Sc. Ch.E., M.A.I.Ch.E. Sixteen years experience research and development, process, project, and sales engineer for petroleum refineries and petrochemical plants. Foreign languages; perfect German, some Dutch and Russian. Now on Engineering consultant assignment in Germany. Seek representation in Europe for engineering or manufacturing firm. Address Box 295-R, PETROLEUM REFINER, Houston, Texas.

OFFICE MANAGER with over forty years experience in refining systems and related work, in California and the East interested in temporary or permanent work, special surveys, investigations, confidential organization reviews, etc. West Coast preferred. Box 297-R, PETROLEUM REFINER, Houston, Texas.

PROCESS AND RESEARCH ENGINEER: Three years' experience D.Sc. (PRE) degree, strong background in Petroleum and Petroleum chemicals. Age 31. Write Box 296-R, PETROLEUM REFINER, Houston, Texas.

Management Position Wanted

Refinery Engineer with 12 years of Process, Project, and Refinery Operations experience with Major Oil Company desires job as Chief Engineer or Operating Manager for expanding independent oil company.

Have personally supervised operations for the majority of refinery units. Also extensive experience in refinery cost control, engineering design, maintenance, and construction. Recent efforts have bee in field of general refinery design for minimum cost.

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Prefer West Coast location.

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Our continued growth has created an opportunity for a chemical or mechanical engineer in our Engineering Division. Ten years' industrial experience is essential. Must be capable of supervising piping, chemical plant layout, and drafting group. Background in building and ventilation design; process, piping, and equipment design to known safety and insurance requirements is essential. Thorough knowledge of pumping, heat transfer, ventilation, structural steel design, welding, and flow of gases and liquids is a fundamental requirement. Initial salary commensurate with training and experience. Advancement based upon merit. Present line of products includes pressure sensitive tapes, chemicals, abrasives, reflective materials, reinforced plastics, adhesives, electrical insulating materials, magnetic recording tape, and printing and duplicating products and others. Location in St. Paul, Minnesota, provides easy access to nation's outstanding hunting and fishing areas.

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ican Gas Association gave him The Charles A. Munroe Award for outstanding contribution by an individual to the advancement of the gas industry in the field of industrial heating. In 1952, he received the first Distinguished Service Award of the Industrial Equipment division of the Gas Appliance Manufacturers Association, Inc. In 1954, he received the nation's top honor for achievement in the industrial heating field, the Trinks Award, for his work in high-speed, fuel fired heat processing.

BORG-WARNER CORP.'S Blaz A. Lucas, Jr., has been appointed manager of sales for the company's Ingersoll Products division. He has been with the division since 1956, serving first as director of procurement and later as factory manager.

Lucas was formerly with Packard Motor Car Co. and the successor firm, Studebaker-Packard Corp. He was on the Chicago district sales staff of the U. S. Steel Corp. for nine years.

WOLVERINE TUBE'S Diamond Key Award has been presented to **Jack B. Chaddock** for a technical paper in the refrigeration field.

This award has been presented annually since 1940. This 18th Diamond Key went to Chaddock, associate professor of mechanical engineering, Rensselaer Polytechnic Institute, for a paper entitled "Film Condensation of Vapor in a Horizontal Tube." The award presentation was made at the Annual Meeting of the American Society of Refrigeration Engineers at Minneapolis.

HILLS-McCANNA CO. has appointed Engineered Instrument Sales Co. of Memphis, Tennessee, its exclusive representative for proportioning pumps and force-feed lubricators. The company will serve Western Tennessee, Northern Mississippi and Arkansas.

Henry A. Petter Supply Co. of Paducah, Kentucky has been appointed a stocking distributor for the company's valves and replacement parts. Petter Supply will serve western Kentucky and western Tennessee.

CREOLE PETROLEUM CORP. has appointed **Glenn E. Guthrie** assistant treasurer and assistant manager of the Treasurer's department.

Before joining Creole, in Caracas, Venezuela, Guthrie was with Standard Oil Co. (N. J.) as senior foreign exchange analyst for Latin America.

STAINLESS PRECISION TOOLS

Stainless Steel T-Squares, Triangles, Straightedges, and Precision Drawing Instruments and Scales. Circular and Linear Engraving to order.

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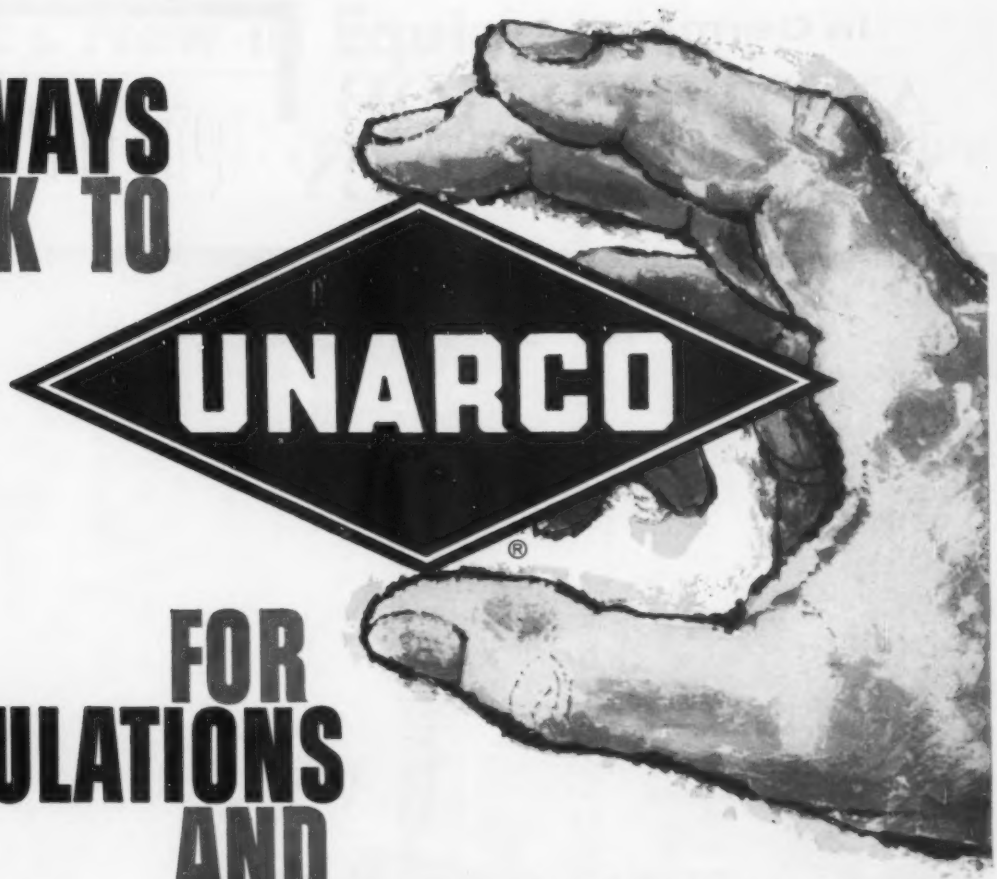

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You know UNARCO, but are you cashing-in on *every* way in which UNARCO can serve you so well? A quick look at the list may point out products you somehow have overlooked, yet all are famous in their fields for progress and performance.

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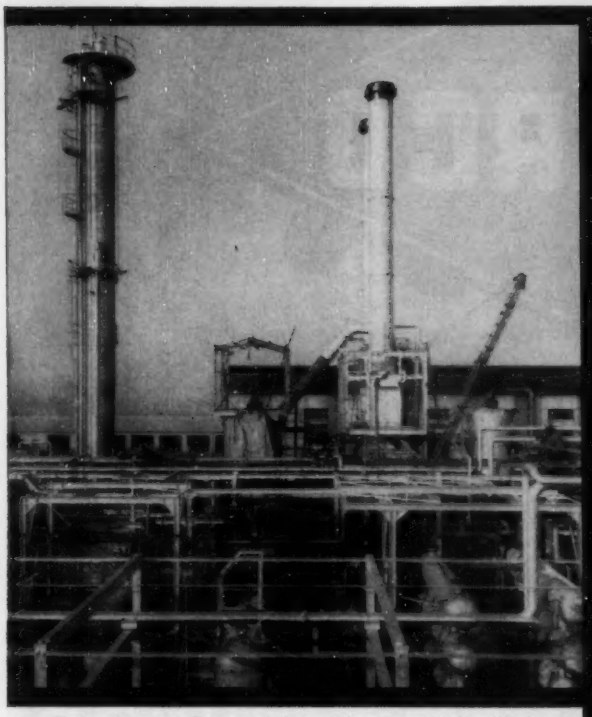
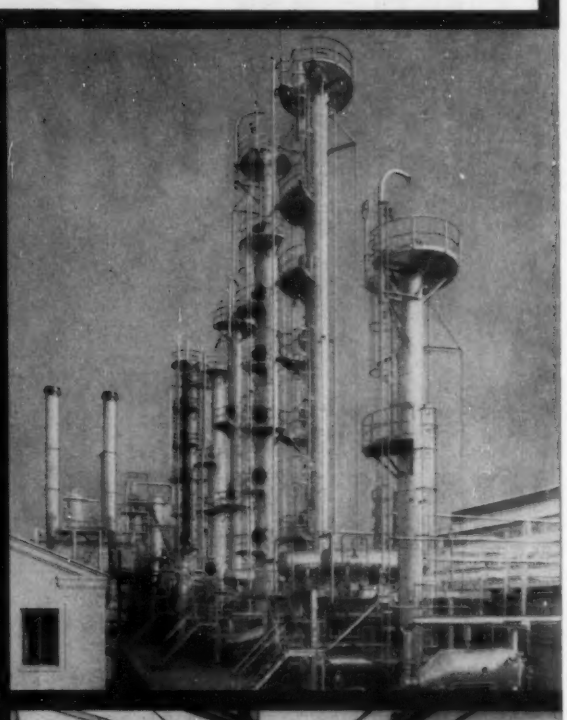




Heat exchanger in foreground, fractionation tower at left and heater stacks on right during construction.

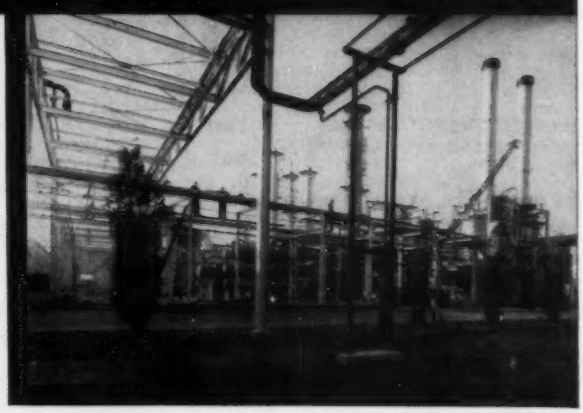
Procon construction helps rebuild Deutsche Erdöl A.G. refinery at Heide, Germany

With a well-planned reconstruction program the Heide refinery of Deutsche Erdöl A.G. Hamburg, is rapidly regaining leadership among European petroleum refiners.

Latest advances in the DEA reconstruction are the Platforming® and Unifining* units recently completed by Procon. With these new units DEA can now supply Northern Germany (Schleswig-Holstein) and parts of Denmark with premium grade gasoline. Formerly premium gasolines for this area had to be transported from great distances. Procon construction was completed on time and up to every specification.

For petroleum refinery, petrochemical or chemical plant construction the world over, remember, "For really fine class work, finished against all odds and finished on time . . . call on Procon."

*Trademark



Top—Fractionation section of the finished Platforming and Unifining units.

Bottom—Nearing completion, heat exchangers, left, in series with the fractionation section and heaters on the right.

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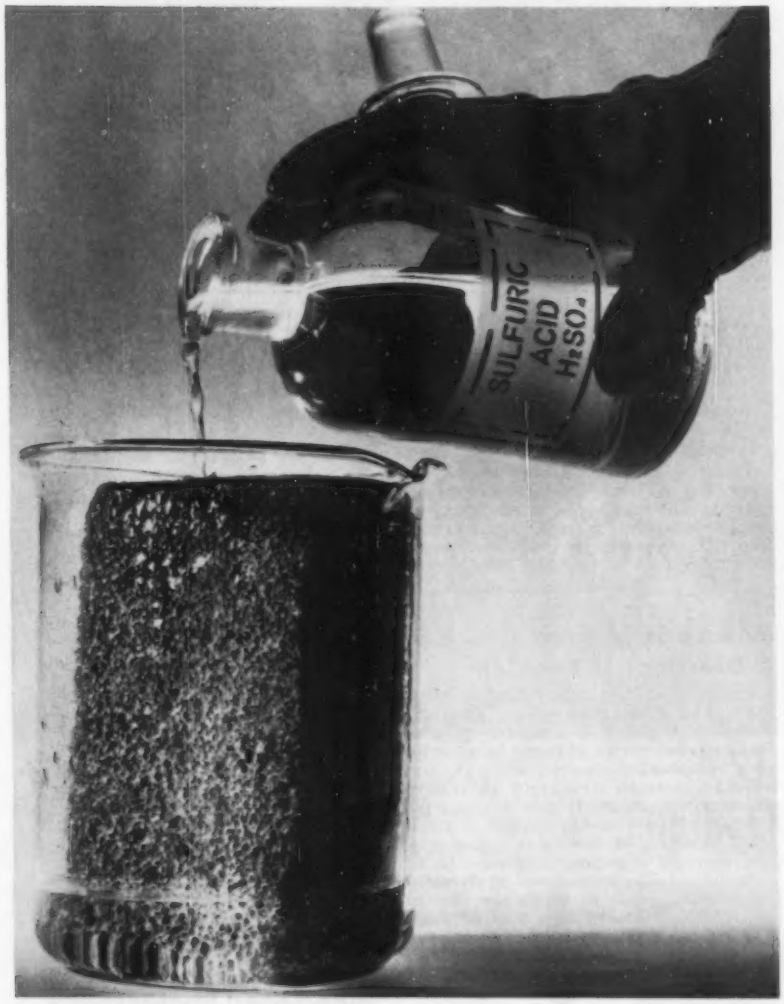

Insulation Unaffected by Acid and Heat

The Pittsburgh Corning Corp. has succeeded in causing pure silica to boil and foam—and in so doing has created an entirely new acid-resistant insulating and refractory material.

The new material, called Foamsil, is 99 percent pure fused silica and can neither oxidize nor absorb moisture. It is unaffected by all acids except hydrofluoric and hot phosphoric.

The material offers continuous insulating protection and withstands thermal shock within the range of —450 F to 2200 F. The insulating value of one inch of Foamsil is equivalent to that of 18 inches of acid brick at an operating temperature of 250 F. The temperature range of the new material is greater than that practical for any other insulating or refractory material currently available to industry.

The pure silica, activated by a foaming agent, foams into millions of tiny, noninterconnecting bubbles. When cooled, a lightweight, rigid, inorganic lock, with a closed cell structure, results.

The dimensional stability of the material is exceptional. It does not warp, shrink or slump during rapid temperature changes. When subjected to intense heat (such as that of a steel-cutting oxyacetylene torch) and then water-quenched, it does not crack or spall.

A low expansion coefficient of 3.5×10^{-7}, about one-eighteenth that of low carbon steel, gives the material volume stability throughout its entire temperature operating range. For operating temperatures up to 2200 F, Foamsil actually expands, whereas most insulations shrink. It has been heated in a furnace at 1600 F for more than two years without any evidence of deterioration. This feature reduces the need for expansion joints and vertical clearances, and virtually eliminates joint separations due to expansion and contraction.

Light in weight (10 to 12 lbs. per cu. ft.) and having a compressive strength of 130 to 210 lbs. per sq. in., Foamsil can be used as a load-bearing surface to eliminate some of the supporting and reinforcing structure required with conventional material.

The material is available in block sizes —11 inches x 17 inches, 17 inches x 22 inches, in thickness up to 3 inches. Greater thicknesses may be obtained by laminating. Approximate cost of the material is $.50 per board foot.

Laboratory and industrial applications show Foamsil to be ideal as a lining inside tanks and pipe lines that contain hot acids of any concentrations. The sealed silica cells prevent absorption of the acids, inflammable solvents or vapors, thus assuring full original insulating value throughout the life of the equipment it serves. Because of the absence of capillary action, Foamsil also cannot act as a wick for transfer of inflammable liquid or gas to critical areas.

Concrete, brick or steel stacks subjected to corrosive atmospheres may be readily lined with the lightweight acid-resistant material. It can likewise be used as underground thermal and electrical insulation. Pittsburgh Corning Corp.

Circle E1 green card, last page

Selection of Expansion Joints Covered in Catalog

A new 80-page catalog covering S-R expansion joints is now available.

The publication includes complete information for rating expansion joints subjected to axial or lateral movement, angular rotation or combinations of these movements, together with formulae and tables for calculating the forces and/or bending movements developed in the connected piping or equipment.

Also included are tables of dimensions and weights for expansion joints from 3-inch to 72-inch in diameter, and other engineering data required to select, order and install S-R expansion joints. Badger Manufacturing Co.

Circle E2 green card, last page

Bulletin Tells How To Figure Venturi Throat Size

Users of Dall Flow Tubes, Venturi Tubes and Venturi Nozzles for the metering of all fluids are faced with the problems of selecting the proper throat size and calculating the head loss in various applications. They also often need to know if a standard throat can be used for steam, gases, and liquids not covered by tabulated

capacities. Simplified formulas and tables for answering these problems are given in a new technical bulletin just issued.

Illustrative examples of formula application are worked out to determine such economic factors as the pumping cost per year for differential producers under typical conditions. The bulletin also contains dimensional tables, capacity tables, and performance charts. Builders-Providence, Inc., a Div. of B-I-F Industries, Inc.

Circle E3 green card, last page

Furnace Tube Selection Discussed in Article

Designers and engineers involved in the selection of furnace tubing for refinery and petrochemical service will find a reprint of technical paper of interest and value. This 11-page article explains the factors involved in selection of the proper furnace tubing for refinery and petrochemical service. It includes tables showing the properties of the different types of tubing steels commonly employed in such service. The Babcock & Wilcox Co.

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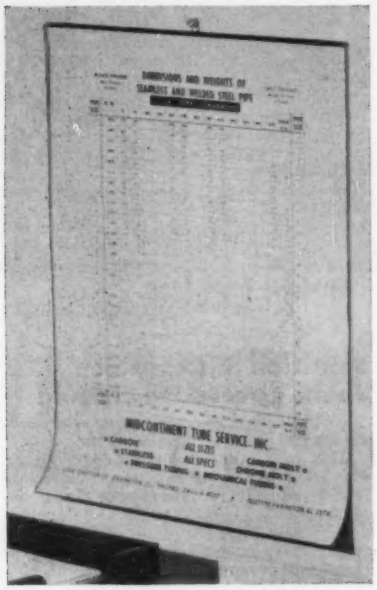

Wall Chart Gives Essential Piping Specifications

Users of steel pipe will welcome a helpful schedule chart now being offered. It's a 17 inch by 22 inch wall chart, printed for top visibility, reproducing all essential pipe-specification information of wall thicknesses, weight and O.D. of seamless and welded steel pipe under ASA schedules from ⅛-inch to 24 inches.

Because of the large size and clear legibility, the chart can be used on a wall for reference from several feet away—thus avoiding desk clutter. Stiffened top and bottom with metal ferrules, the chart will hang flat on any wall surface. Midcontinent Tube Service, Inc.

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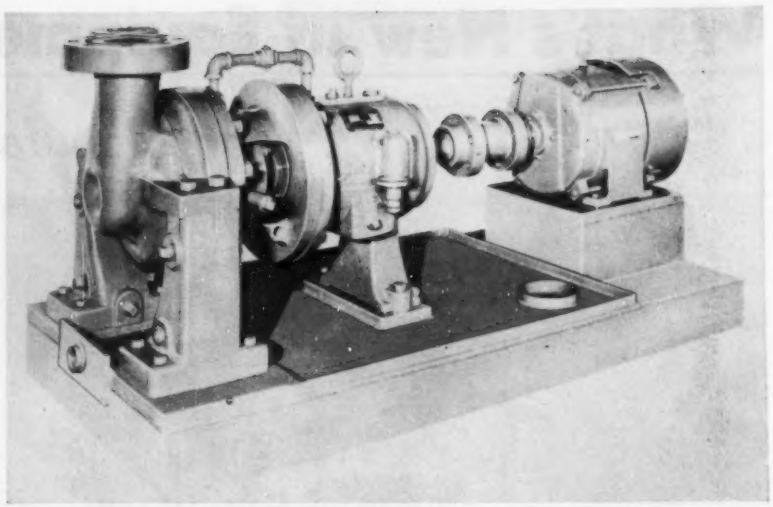


Pumps Feature Parts Interchangeability

A new line of heavy duty centrifugal pumps for refinery and process service has just been announced.

Designed as Series R-200, the line incorporates API and major oil company specifications together with maximum interchangeability of parts. Capacities range from 25 to 1,000 gpm with total heads to 650 feet in a pumping temperature range from minus 150 F to plus 850 F.

As in all of the company's standard centrifugal pumps, the stuffing box in Series R-200 is designed to accommodate either a mechanical seal or packing, interchangeably, without any modification of pump. Dean Brothers Pumps, Inc.

Circle E6 green card, last page

How To Strip Paint Is Described in Booklet

Four methods commonly used by leading industrial plants to remove paint are described in detail in a new booklet. It first describes twelve different paint stripping compounds—alkaline, solvent, and solvent-acid—each designed to remove different type paints. It then discusses the company's Hot-Flow-On method of stripping, consisting of flowing stripping solution through a perforated pipe rake or shower-head. The second method discussed is tank immersion, in which the part to be stripped is soaked in a tank of stripping solution. Third is the steam gun method in which steam is combined with the stripper and flowed on the surface through a steam gun. Brushing is the fourth method: stripper is brushed on, allowed to soak and rinsed off.

The booklet also discusses treatment of metals before repainting, and prevention of rust on stripped surfaces in storage. Oakite Products, Inc.

Circle E7 green card, last page

Bulletin Describes Fired Heaters For Severe Service

A colorful 8-page bulletin shows principal design features of standard types and special design fired heaters as required for unusual services. It includes drawings and description on special fired heaters for severe services. Also included are photos of typical installations in plants of most important petroleum and chemical companies. Struther Wells Corp.

Circle E8 green card, last page

High Speed Photography Develops Impact Wrench

High-speed photography used in conjunction with an extensive study of tool impacting operations has led to the development of a new impact wrench.

Analysis of speed films at the company's research and development laboratory revealed some heretofore unknown data that resulted in the design of an entirely new impacting mechanism and the new wrench.

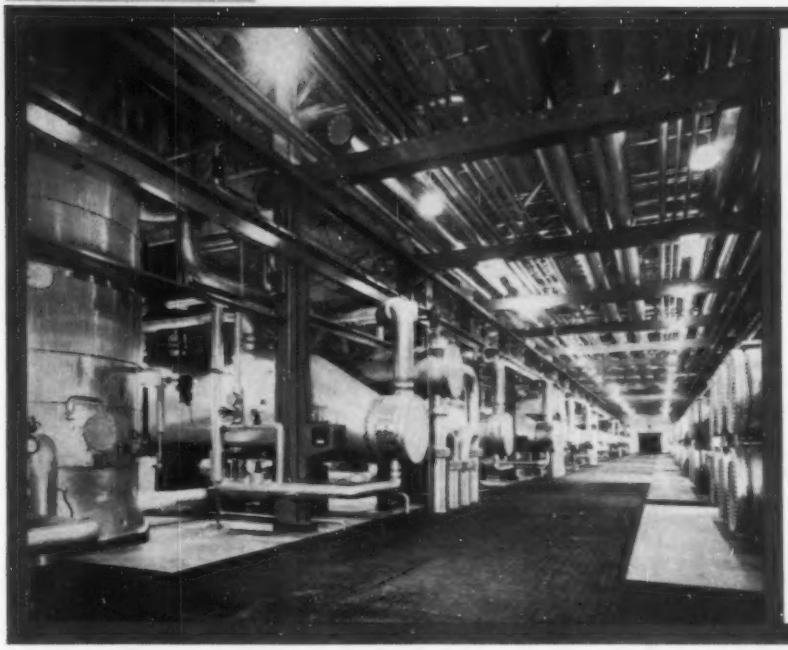
Company engineers state that the new impact wrench has undergone rigid field testing, and on some of the toughest impacting assignments has proved to have the ruggedness and reserve capacity for extended periods of operation. Also, maintenance problems common to impacting mechanisms have been greatly reduced.

The new wrench is available in two models. Both feature light weight and small dimensions, and are rated at ¾-inch nut-setting capacity. Model 18B-7 is equipped with ¾-inch square drive and

In Less Than Two Years . . .

STEARNS-ROGER PLAYED A MAJOR ROLE IN

GAS FOR B. C.



The McMahon plant of Pacific Petroleums Ltd., for natural gas beneficiation, liquid recovery, and motor fuel manufacturing at Fort St. John on British Columbia's Peace River was less than two years from contract to operation. The design, engineering and construction utilized Stearns-Roger resources and facilities in both Canada and the U. S. to complete the assignment within the projected time.

The special weather protection problems were routine because of Stearns-Roger's years of experience in cold country process plant engineering. The resultant attention to details of design assured trouble free operation under outdoor weather conditions of 60 degrees below zero.

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PRESSURE CONTROLLERS for high or low-limit cutoff or signalling, or for control of pressure and vacuum in many ranges from 0 to 1000 psi.

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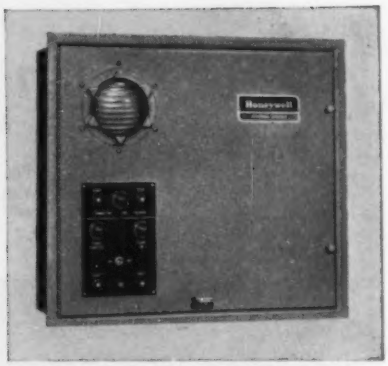
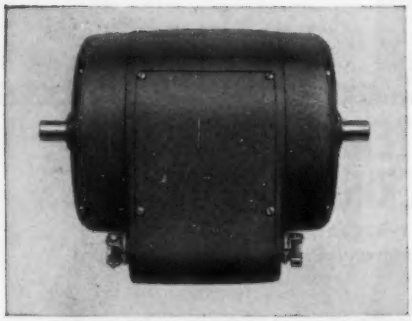
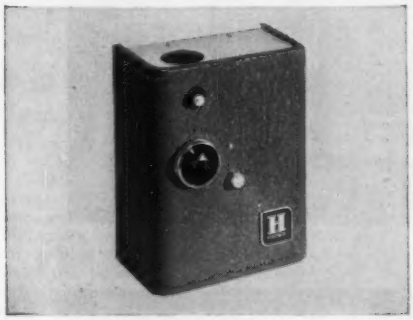


***PROTECTOGLO* FLAME SAFEGUARDS** instantly detect flame failure in gas or oil fired burners, and immediately shut off fuel supply, sound an alarm, and perform other functions to guard against explosion hazards.

Add low-cost automation ...with Honeywell industrial controls



INDUSTRIAL MOTORS for electrical operation of valves, dampers and auxiliary switches.



ALARM SILENCING RELAYS permit an alarm to be silenced, and light an integral red light until an unsafe condition has been corrected. Relay automatically resets the alarm when safe conditions are restored.

You don't have to spend a lot of money for dependable automatic controls. Like many manufacturers, you can use various Honeywell industrial controls as the efficient, low-cost means of automating your equipment . . . improving performance . . . increasing safety. And, you can use these inexpensive controls to save time, money and space by extending automation in your plant or process.

There are more than 9000 standard types of Honeywell controls to handle temperature, pressure, liquid level and humidity—for control, switching or safety functions. There are electric, electronic and pneumatic types.

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New Equipment . . .

Model 18B-7S has ⅝-inch built-in hexagon slip chuck. Accessories for the wrench include stud drivers, socket adapters, hexagon shank socket holders, and universal joint socket adapters. Gardner-Denver Co.

Circle E9 green card, last page

PVC Dump Chute Protects Glassed-Steel Reactors

The much used and often misused manhole opening on glassed-steel reactors can now be protected during charging by using a polyvinyl chloride dump chute.

The top head manhole is the most vulnerable area on a reactor since it is glassed to the outer edge of the flange. Damage to the glass can occur when the vessel is improperly charged, especially with abrasive or solid materials. The plastic dump chute is designed to fit inside the 12 inch by 16 inch manhole and protect both the flange and neck of the opening. Simple to place and remove, it provides further insurance for long term service life of glassed-steel reactors. The Pfaudler Co.

Circle E10 green card, last page

Insulated Check Valve Stops Electrolytic Action

A new top entry double union check valve for oil process lines, first to be insulated against electrolytic action, has just been designed. It features a precision manufactured bronze clapper, engineered to provide quiet operation and effective closure when the flow pressure drops. Full opening passage is provided for line cleaning and removal of paraffin and other deposits.

Quick removal and replacement of parts is possible through the valve's top entry. A threaded, top entry cap with an octagon-shaped head, available with a non-corrosive O-ring, has been designed for fast opening and pressure-resistant closure.

Design of the valve eliminates the use of a nipple and full union necessary to install regular check valves. If the union is opened on the inlet side, the valve will prevent pressure in the line from reversing the flow.

Insulation against uncontrolled electric currents is available in one union end. This feature prevents expensive damage from galvanic action to pipes and equipment in the flow system.

Engineered for 2-inch diameter pipes, the valve operates under pressures up to 500 pounds water-oil-gas, or 300 pounds steam. It is available with forged steel double union ends or female pipe ends. Clayton Mark & Co.

Circle E11 green card, last page

Lightweight Flanges Have Broadened Service Ratings

New ratings broadening the service range of its lightweight forged steel taper face welding neck flanges have been announced by Tube Turns.

On the basis of extensive fatigue and bending tests under simultaneous pressure, the flange is now recommended for 175 psi liquid, gas or air service at 150 F. Originally the flange was rated at 125 psi WOG (water, oil and gas). It is now rated suitable for 125 psi dry saturated steam at 353 F.

The new ratings correspond with the steam rating of Class 125 cast iron or "semi-steel" valves, substantially increasing the range in which the flange can be used in steam service.

Dimensions match cast iron flanges and valves having Class 125 flanges in accordance with ASA B16.1. Its tapered face and modified hub are especially designed to achieve a better seal by exerting greater pressure near the flange bore.

One-third to two-thirds lighter than standard ASA 150 pound welding neck flanges, the new flange reduces both weight and costs, the announcement said. Also, it said, the flange eliminates the need to use heavier and more costly high-pressure class flanges and valves for low-pressure service, eliminates the need for special gaskets, and eliminates the extra cost of boring standard flanges to match light weight pipe. Tube Turns Division of Chemetron Corp.

Circle E12 green card, last page

Magnetic and Motorized Valve Specs. in Catalog

In 34 pages, Catalog V-58 illustrates and lists specifications of magnetic and motorized valves for use with air, water, gas, steam, oil and refrigerants. Also included are solenoid coil rating tables. Another feature is two flow charts, one for liquids, the other for compressible fluids. Dimensional drawings are included. The Mercoid Corp.

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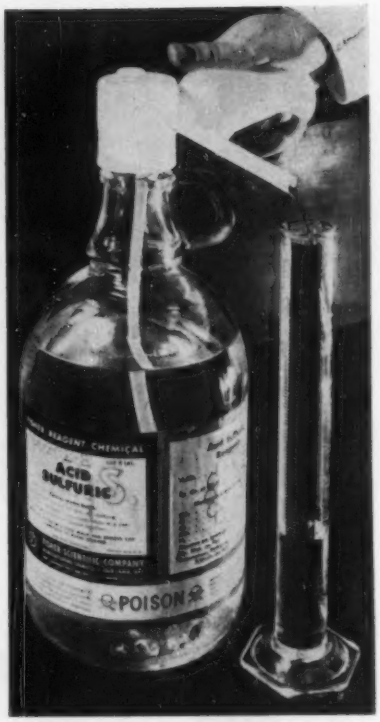

Safe And Simple Is the New Polyethylene Acid Pump

For the safe, convenient and contaminant-free handling of just about every kind and concentration of corrosive, polyethylene can't be beat. That's why the unique new SAF-T-PUMP for acids is all-polyethylene.

The SAF-T-PUMP screws onto any standard 5-pint acid bottle. Attached to the pump body are a siphon, a spout and a 4-ounce squeeze bottle, all polyethylene. Once screwed onto the bottle, the unbreakable pump delivers acid at the rate of 100 ml/minute with just light, rapid squeezes of the squeeze bottle. There is no after-drip from the spout; merely press the pump's relief-valve button to stop flow. Fisher Scientific Co.

Circle E14 green card, last page

Hard-Surfacing Electrode Has Low-Temp. Toughness

A new composite-coated hard-surfacing electrode, deposits of which exhibit exceptional toughness at low temperatures, is now available. Designated Walmang No. 3, the new nickel-manganese alloy is a work hardening material that provides

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Today, modern oil refineries and chemical plants require more and more complicated pieces of fabricated equipment—too large to ship by rail or road. To meet this need, Sun Ship specializes in building and shipping large carbon or alloy steel units by water (inland, coastal or overseas)... directly from our plant.

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New Equipment . . .

good wear resistance and excellent impact resistance. As deposited it is extremely tough, even at below-zero temperatures.

Walmang No. 3 is easily deposited, operating equally well on either AC or DC reverse polarity. Its low hydrogen coating produces, solid, non-porous deposits, contributing to the material's toughness. It is recommended for hard-surfacing manganese and carbon steel castings or forgings of all kinds. It is particularly well suited to such applications as rail frogs and switches, crusher screens, coal crusher segments, shovel teeth, dredge parts, hammers and other equipment subject to heavy wear.

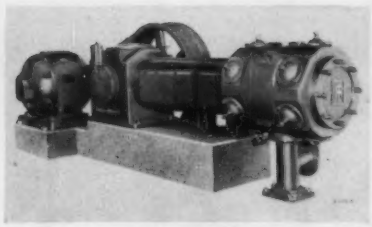
The new material deposits at approximately 229 BHN; it work hardens in service to as high as 555 BHN. Walmang No. 3 conforms to AWS-ASTM Classification EFeMn-A covered. It is packed for shipment in hermetically sealed steel cans. Wall Colmonoy Corp.

Circle E15 green card, last page

Catalog Tells How To Select Welding Fittings

Weldolets, Threadolets and Sockolets are all covered completely in a new catalog on these welding fittings. Complete engineering data for the selection of these fittings and others are described in this 41-page catalog. Bonney Forge & Tool Works.

Circle E16 green card, last page



Compressor Works Where Gas Can't Contact Oil

A new line of non-lubricated compressors is now being built for heavy-duty service where the air or gas being compressed cannot be allowed to contact oil or other lubricants.

These ESH-NL compressors have special compressor cylinders which require no oil or other lubricants, due to use of self-lubricating materials in pistons and packing, as well as special "NL" channel valves. They use the same frame and running gear as the company's ESH horizontal compressor, and are also available as vertical units (called ESV). Ingersoll-Rand Corp.

Circle E17 green card, last page

Flowmeter Handbook Gives Basic Engineering Data

A new 15 page Variable-Area Flowmeter Handbook gives basic engineering data including tables, and graphs and equations for application, sizing, and flow rate calibration prediction of low flow rate rotameters. Fischer & Porter Co.

Circle E18 green card, last page

Nomograph for Sizing Chemical Feeding Systems

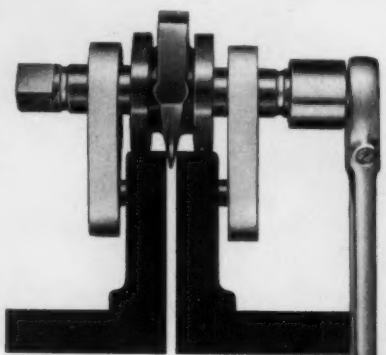
Throughout the process industries, wherever chemicals must be metered accurately to continuous streams, design engineers must determine the ideal capacities for the controlled volume pump and the chemical holding tank. The calculations are simple and well known to chemical engineers, but they take time and are subject to errors. To enable chemical engineers to calculate the correct sizes in a matter of a few seconds, a nomograph has been developed.

To use the nomograph, one must know the concentration of the chemical solution to be metered, the required chemical dosage, and the flow rate of the process stream. Using this information to draw two straight lines on the nomograph, one can learn the necessary pump capacity in gallons per hour and the number of gallons of tank holding capacity needed if the tank is to be refilled every 8, 12, 16, 24, 36 or 48 hours. The nomograph also gives the sizes of pumps that are 20, 50 or 100 percent over capacity, for use when these margins of safety are desirable. Milton Roy Co.

Circle E19 green card, last page

High Corrosion Resistance With Nickel-Coated Valves

A special line of nickel-coated lubricated plug valves especially applicable in the refining and chemical industries is now available. The new nickel-coated valves have the same qualities of corrosion resistance as higher-cost solid nickel or stainless steel valves and with improved



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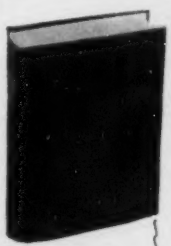
With a "Safety Boy" you can spread all types of flanged pipe connections **in seconds,** not hours — to insert blinds, gaskets, orifices. Plant safety hazards and costly down time are eliminated by switching to this really modern pipefitter's tool — "Safety Boy." Wherever there's piping there's a need for "Safety Boy" — the handiest tool ever invented for work in cramped quarters. Lightweight and easy-to-carry, "Safety Boy" is reasonably priced for wide usage.



Hundreds of practical tips on:

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Instructions in this volume are so complete and so exact they enable an engineer or foreman to *thoroughly supervise* the job and a mechanic to *actually perform* the work. In fact, with the help of this book, anyone responsible for pump operation and maintenance will now find it possible to set up a complete program covering the pumping facilities in any plant—from the largest having thousands of pumps to isolated stations having a single, small pump.

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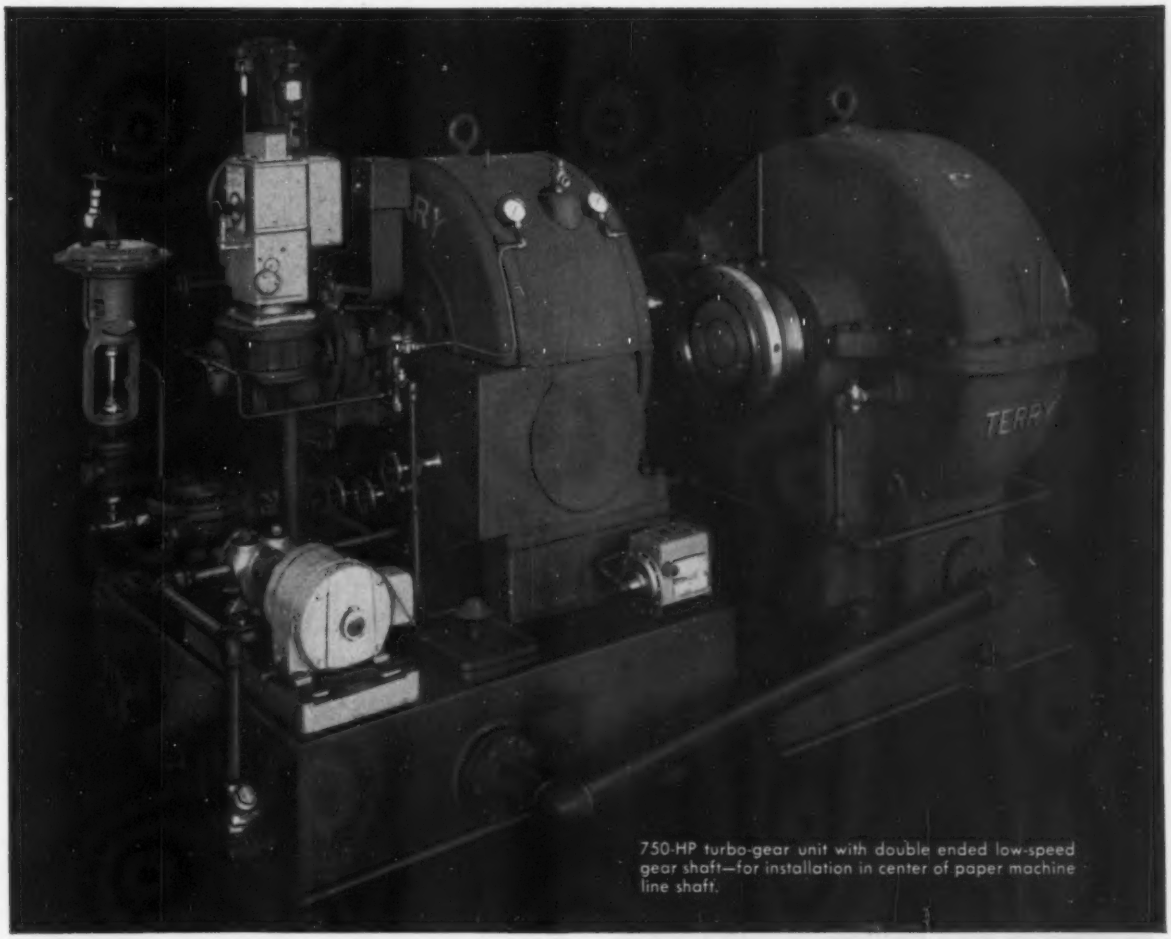

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tailored to meet your requirements

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Whatever *your* requirements for low-speed turbine drives, a Terry engineer will be pleased to discuss them with you. Bulletin S-140 covers the full line of Terry turbines; Terry gears are described in bulletin S-130.

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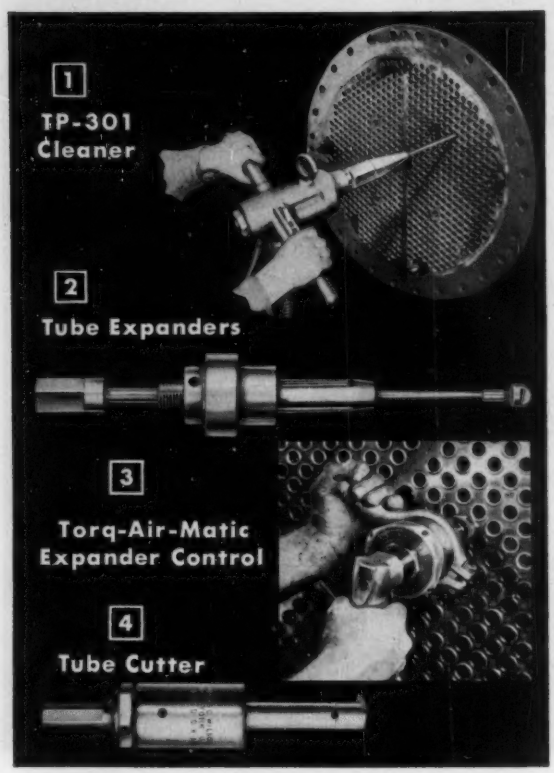

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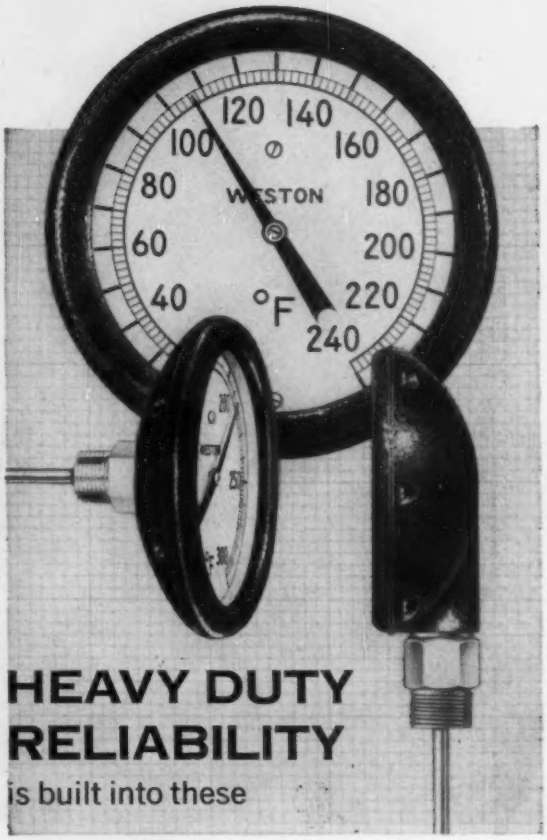

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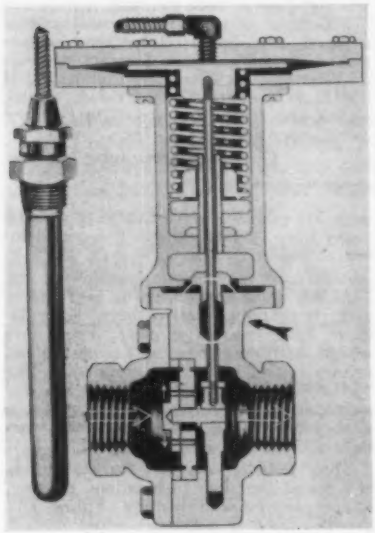

Control Valve Has Teflon-Asbestos Stem Packing

The OPW-Jordan Temperature Control Valve now incorporates Teflon impregnated asbestos stem packing. This packing is inert, durable, and trouble-free. It will not shrink, swell, or deteriorate, and it is self-lubricating. The resulting easier valve stem movement allows diaphragm power to be transmitted more accurately to the sliding gate seat. These valves are available in ¼-inch through 2-inch sizes; 125 WSP cast iron and 250 WSP bronze bodies. Jordan Industrial Sales division of OPW Corp.

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Vertical Drafting Machines Boost Drawing Efficiency

An entirely new concept in drafting equipment promotes efficiency in the drafting room. The precision equipment is made in Germany and eliminates the strain ordinarily associated with a horizontal drafting board. The new machine can be tilted to any position from vertical to horizontal without necessitating a move by the draftsman.

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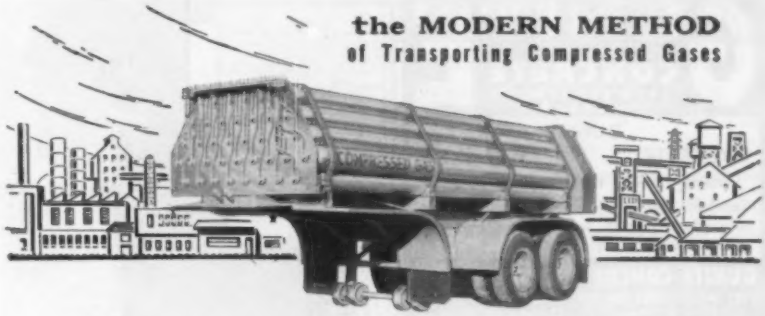

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zontal boards, show that between 50 and 70 percent of drafting errors and inaccuracies occur when working at the top of the board where maintenance of a convenient working position is most fatiguing. The Kuhlmann machine eliminates that strain by allowing the draftsman to position the board for maximum comfort any place on the board. Impex Inc.

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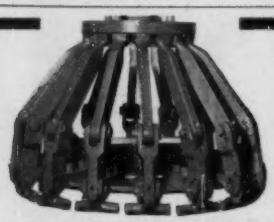

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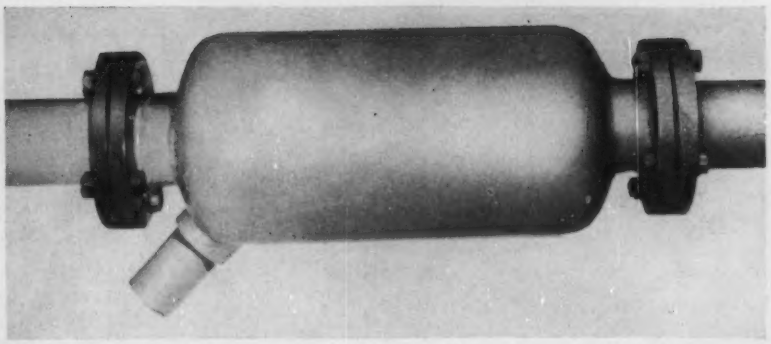


Separators Remove Nearly All Entrainment

Hi-Line, high efficiency, line separators eliminate entrainment from vapor and process lines. Installed directly in the operating line, either horizontal or vertical, the units remove almost 100 percent of all entrainment at a higher capacity than other types of line separators, according to the manufacturer.

The separators utilize to the fullest possible extent the superior qualities of knitted wire mesh for entrainment removal. They also utilize expansion impingement, change of direction, and liquid scrubbing to effect a much more complete separation of liquid and vapor.

The units are built in accordance with the ASME code for unfired pressure vessels and may be code stamped, if required.

Separator vessels are normally constructed of carbon steel but may be furnished in stainless steel. Internal elements are standard in Type-304 stainless steel but may be obtained in T-316, monel, nickel, etc. A.C.S. Industrial Div., American Copper Sponge Co., Inc.

Circle E23 green card, last page

Plastic-Steel Container Gives Lower Package Costs

A new plastic-and-steel returnable container for the shipment of corrosive chemicals is now being produced.

The new container, which bears the tradename "JALboy," consists of a polyethylene inner container with a steel drum outer jacket. The "JALboy" is being made in two sizes: standard weight 14-gallon with 5¾-pound inner container), and the heavy duty 13-gallon (with 8¾-pound inner container).

According to Company engineers, the "JALboy" offers numerous advantages over conventional glass carboys. These include lower package cost; lower tare weight, and less cubage with a consequent savings in freight and handling costs. The "JALboy" weighs only 23 pounds, approximately one third of the weight of a glass carboy. The cubage is about one-half.

The "JALboy" also has the advantages of a round container in handling, pouring, stagger storing and loading. Filling and handling time is reduced.

Safety hazards are reduced and service life is extended by the unbreakable polyethylene container in a rugged steel container. The exterior of the steel container is coated with a phenolic based material to resist corrosive atmospheres and spillage. The cover can be obtained coated with 8 to 12 mils of Polyvinyl Chloride as a protection against spillage corrosion.

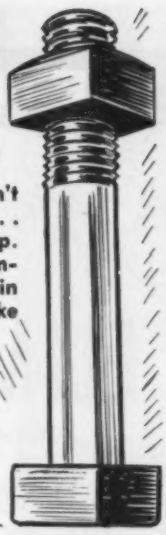
The neck and cap of the polyethylene container protrude through a 4½-inch diameter curled and gasketed opening in the cover of the steel drum jacket. If necessary, the steel outerpack can be removed and replaced by a new container and installed by the user with a two-lug closing tool. Jones & Laughlin Steel Corp. and Plax Corp.

Circle E24 green card, last page

Cyclone Tubes Guaranteed For 100 Months Service

Cyclone tubes, once the weak spot in mechanical dust collecting systems, have been enjoying increased life expectancy in recent years as a result of better designs and improved materials. But because of widely varying conditions under which such systems are used, tube life was con-

BIGGEST THING in YOUR SHOP...



When some rusty bolt or shaft won't let go and it is tying up production . . . it can be the biggest thing in your shop. That is when Kano Kroil, the new chemical loosener, is worth its weight in gold. As one customer put it, "It's like an extra employee."

. . . "Five men, total weight of 825 pounds, using levers and sledges, struggled for an hour with a frozen shaft. No luck. So all went out for a smoke. One man, weighing 140 pounds used Kroil and by the time we returned, had lifted the shaft out with no leverage."

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Third Edition, 328 *pages*, 6x9, 70 *illus.*, $6.75

Engineers encountering a growing number of problems in this field will appreciate the directness of the treatment. Third edition includes new chapters on fluid flow in the convection process and graphical and numerical methods applied to heat conduction problems.

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For more data on advertised products, use Readers' Service Cards, last page.

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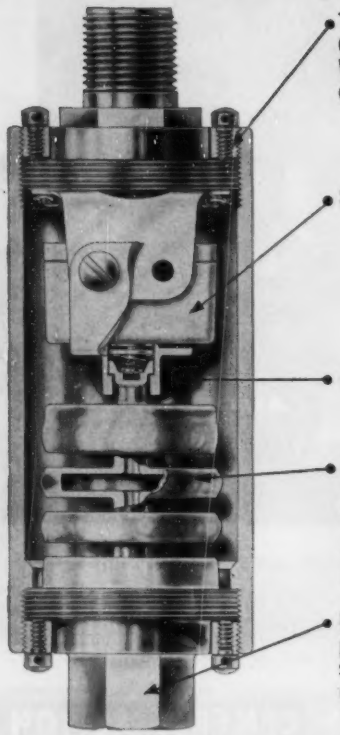
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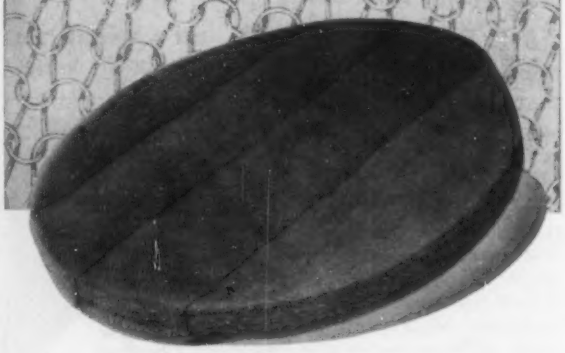

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Ask Metex for engineering recommendations. Write today for Bulletin ME-6 and a data sheet.

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sidered too variable for a general warranty.

Now a new tube has been developed which the manufacturer says will be guaranteed for 100 months. The tubes are white cast iron, highly resistant to corrosion and wear, and if failure occurs during the first 36 months of operation, new tubes will be furnished at no charge F.O.B. factory. Thereafter, replacement will be made at a pro-rata charge based on 100 months of warranty.

Circle E25 green card, last page

52-Page Catalogue Tells About Flame-Proof Lighting

A new 52-page catalogue and data book giving detailed specifications, illustrations, installation recommendations and data on a line of certified flame-proof and weather-proof industrial lighting fittings is now available. Victor Products, Ltd.

Circle E26 green card, last page

How To Splice Wire Rope Described In Handbook

A highly illustrated 38-page handbook on splicing techniques is now being offered. The book is one of a series of educational handbooks available from this manufacturer to help wire rope users obtain longer life from their wire rope and acquaint them with certain safety standards to be maintained in the use and care of wire rope.

This handbook covers various eye splicing methods, endless splices, performed and Lang Lay wire rope splicing and the Chicago technique. In addition, the subjects of grommets, socketing of ferrules and efficiencies of wire rope attachments are covered—together with an engineers notebook on wire rope constructions and specifications. Union Wire Rope Corp.

Circle E27 green card, last page

Line Filter Requires No Tools For Servicing

The Plenty Patent Filter is a line type filter designed to meet the requirements of the process industries, in particular. No tools are required for servicing even the largest filter, because it contains its own operating hand screw and cover. There is virtually no spillage when removing the filter cage for cleaning. There is no need to renew the gasket, since a special synthetic 'O' ring joint is used which is self-sealing under vacuum or pressure, and will withstand long use and repeated removal and replacement of the cover. Plenty & Sons, Ltd.

Circle E28 green card, last page

Fluid Cracking Catalyst For Special Conditions

A newly-developed Aerocat fluid cracking catalyst is now available in commercial quantities. It is designed for selected refinery situations in which certain operating conditions, such as heavy metals contamination, exist. Priced at $225 per dry ton, production of the new catalyst maintains the company's position as a leading supplier of a complete line of fluid cracking catalysts to the refinery industry.

According to the company, extensive testing of the new commercially-produced catalyst on principal types of gas oils shows that it has outstanding physical and catalytic properties.

Developed by the research and manufacturing departments, the new catalyst is designed for service in both new and existing facilities. Amercan Cyanamid Co.

Circle E29 green card, last page

New Equipment . . .

Kettle Cuts Grease-Making Maintenance

A self-contained, electrically-heated kettle solved a facility expansion problem for the Atlantic Refining Co., when more high-temperature grease-making capacity had to be installed.

Rather than enlarge its present Dowtherm heating system to take care of a new conventional kettle, install a larger boiler, additional pumps, etc., the company found it more economical to install an Electro-Vapor kettle. The new unit has a self-contained supply of Dowtherm, and is equipped with electric immersion heaters. This is a completely new application to the grease industry, although the principle has been proven in several hundred applications in the chemical industry.

The Electro-Vapor kettle combines the advantages of electrical and Dowtherm heating without the disadvantages of conventional Dowtherm equipment maintenance problems. Operating temperatures up to 700 F are possible so that a single unit can be used to make a wide variety of greases.

Atlantic engineers also found that this new arrangement, with its fewer pieces of auxiliary equipment, would entail less maintenance work, and the new kettle's heating efficiency would be practically 100 percent higher when compared to the 75-80 percent of an oil or gas-fired boiler. Its full heating efficiency is maintained regardless of the rate of heat input needed by the process, and there is no boiler maintenance to require periodic shut downs. Electro-Vapor kettles have operated continuously for over five years at a time without a single bit of maintenance. Buflovak Equipment division, Blaw-Knox Co.

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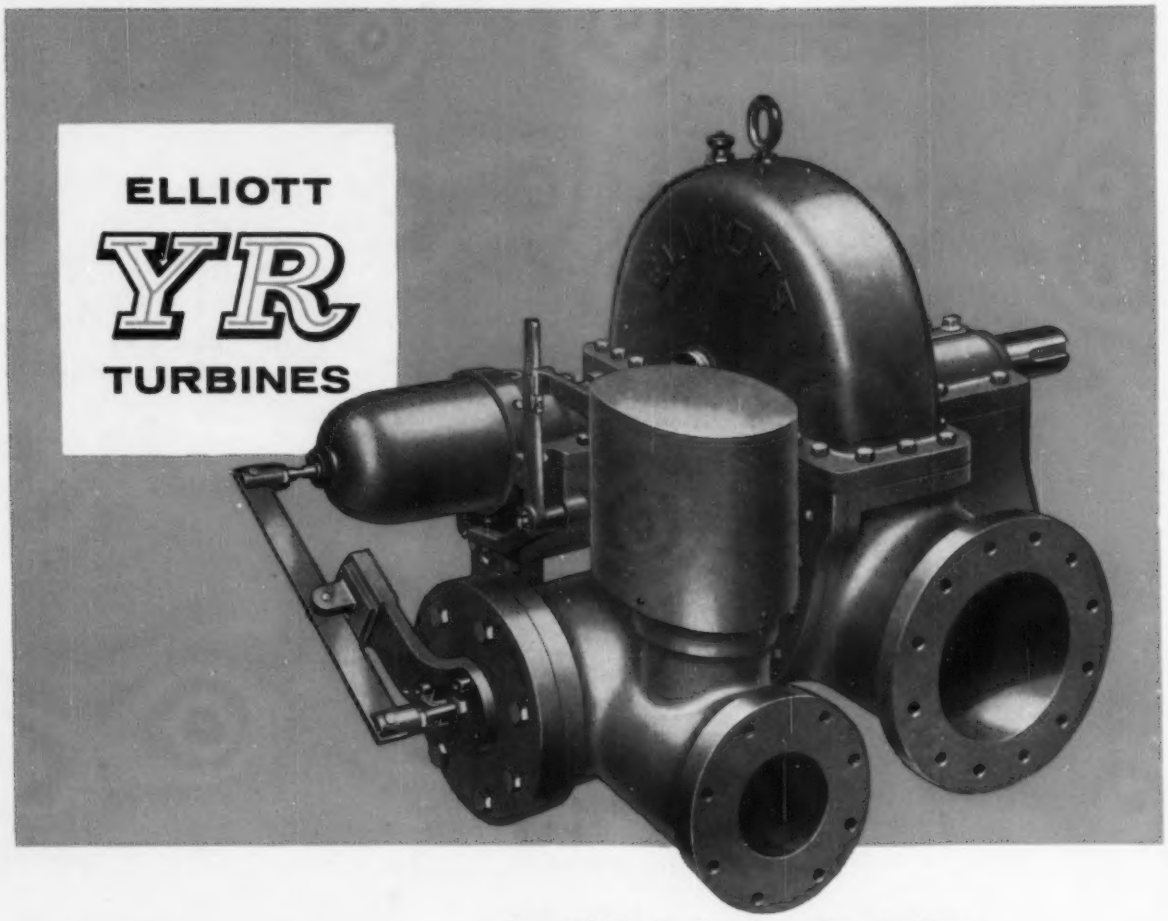

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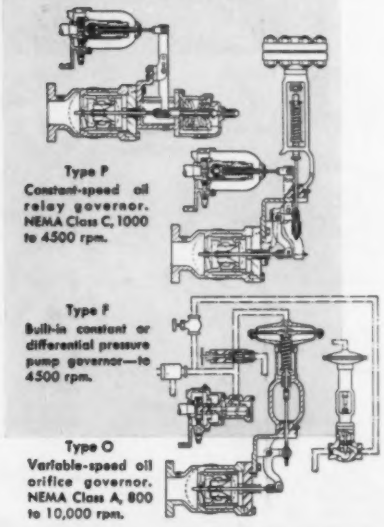

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